PHD

The development of a micro-computerised plant establishment and growth model for use with landscape taxa

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THE DEVELOPMENT OF A MICRO-COMPUTERISED PLANT ESTABLISHMENT AND GROWTH MODEL FOR USE WITH LANDSCAPE TAXA

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Frank Hope

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ABSTRACT

This study investigates the feasibility of a micro-computer based plant establishment and growth model, which can be used as a means of storing and manipulating information relating to the cultivation of decorative landscape taxa in England and Wales.

The work includes four experiments in establishment husbandry, which investigate the feasibility of field work to provide information on specific ornamental husbandry practices.

The study investigates computerised plant establishment and growth modelling in relation to climatic and site requirements, and the production of a micro-computer programme to enable the formulation of accurate predictions of plant performance.

The work highlights the requirements of modern landscape management and has brought together environmental data essential for the formulation of accurate establishment and growth predictions.

The computer model demonstrates the potential for such a predictive approach to selecting landscape plants. All data are formatted for inclusion in a practical working landscape based model, including the ability to predict the suitability of taxa for climatic, site and specific intolerances.

PREFACE

There is a distinct need for readily available information relating to the interaction between both landscape design and the horticultural performance of decorative taxa. Yet, there is a dearth of knowledge in respect of specific site and climatic interactions with such plants.

The current work explores the issues of what the necessary requirements for successful establishment and growth are, and the ways of evaluating and treating a site to gain the maximum advantage from it.

The work has resulted in a functional micro-computer based assessment model which has been developed to enable the rapid identification of climatic and site related factors which are known to affect the establishment of ornamental taxa on landscape sites.

Any successful project of this nature is by necessity diverse, and must encompass areas such as computer science, climatology, landscape design and horticultural technology. Because of this diversity the project is presented in three sections; these are :

1. A computer programme.
2. Horticultural and landscape related aspects of plant assessment models.
3. A user manual for the micro-computer model.

Part one of the work, i.e. the programme proper and its related data-files, is contained on a number of floppy discettes. Parts two and three have been bound separately.

SECTION I

HORTICULTURAL AND COMPUTER CONSIDERATIONS INFLUENCING THE DEVELOPMENT OF A LANDSCAPE ASSESSMENT MODEL

1.0 INTRODUCTION

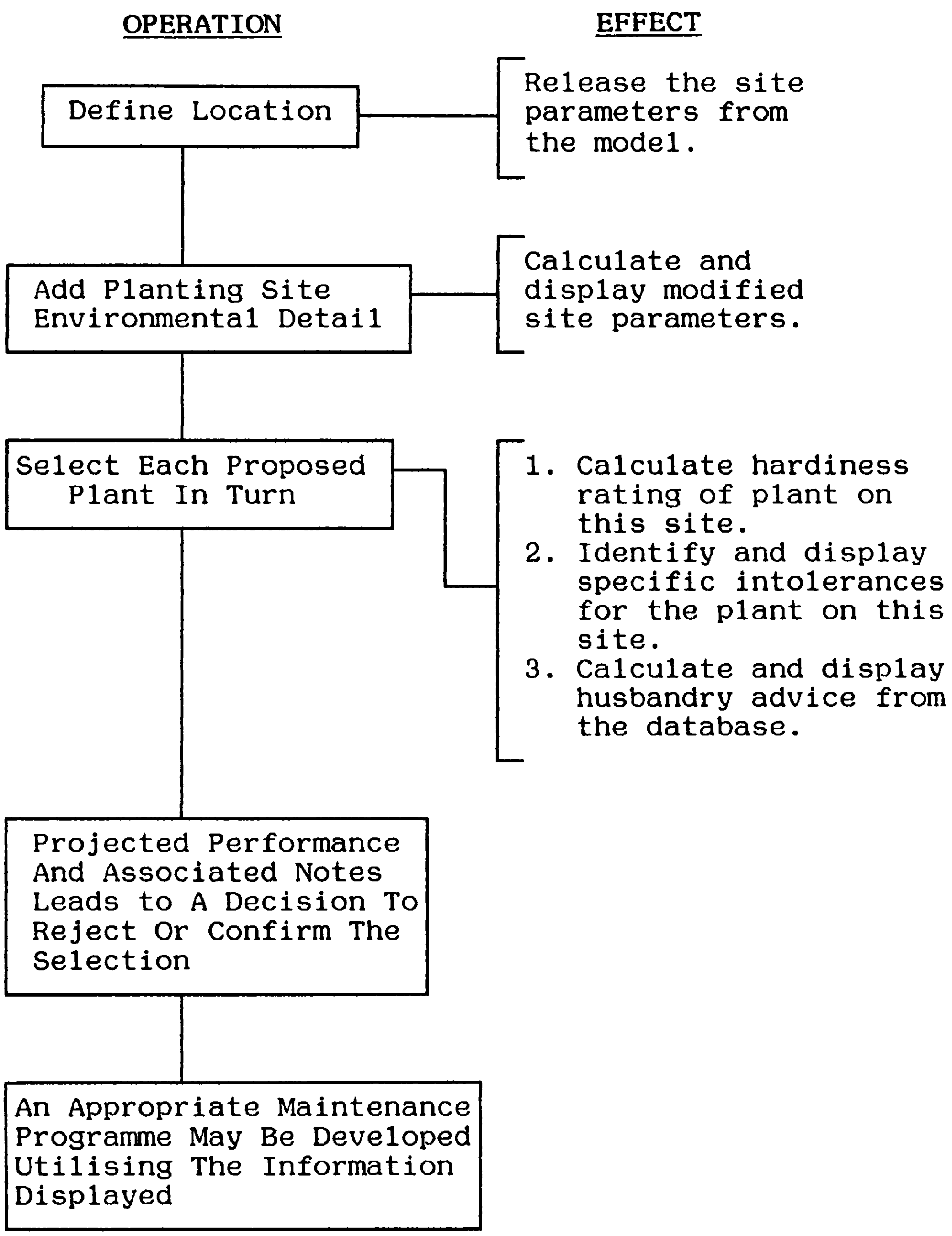
The growth and development of amenity plantings can be described in terms of design intent over time. What this implies is that a landscape designer attempts to visualise or predict how taxa will grow within their allotted space and environment. Ideally, plants would grow at a predictable rate, and achieve their optimal shape, dimensions and decorative features within a calculable time scale; unfortunately, in contemporary landscapes, this rarely occurs.

It is perhaps even more important for the landscape designer to be able to identify those factors that will reduce plant performance, and predict the effect these will have on specific taxa. This would then allow the selection of one of the three following options :

1. Reject the plant as unsatisfactory.
2. Modify the environmental conditions to aid establishment and growth.
3. Use the environmentally modified growth form, e.g. "Scrub Oak", to design advantage.

The following schematic diagram summarises the overall ambition of the project :

Figure.1 Schematic diagram to summarise the Assessment Model



Theoretically, using genetically stable taxa in known conditions, it is possible to calculate the standard growth rate of plants (Hunt, 1982). For example, relatively accurate predictions can now be obtained for a range of agricultural crops, such as cereals. Unfortunately, in contemporary ornamental plantings, the interrelating complexity of prevailing site, soil, climatic conditions and genetic diversity, makes the accurate prediction of growth extremely difficult.

Since the advent of high speed micro-computers a number of attempts at predicting the growth and establishment of specific agricultural and forestry crops have been made. However, little work has been carried out relating to ornamental taxa.

The aim of the current project has been to store and manipulate climatic, site, soil and taxon related data in such a way as to aid the prediction of establishment and growth in a wide range of locations and conditions. It also highlights the problems which exist between site preparation, planting and subsequent maintenance of modern landscapes as opposed to more traditional plantings.

1.1 TRADITIONAL HORTICULTURAL PRACTICES

Horticultural husbandry practices in the past were based upon empirical knowledge, observation and personal intuition. Many traditional techniques, which were initially developed in private estates and local authority parks departments, were passed down from one generation to the next. In these establishments there were few time restraints and the emphasis tended to be on quality of work rather than speed. This resulted in horticulturalists cosseting their plants by lavishing attention on site preparation, planting and subsequent maintenance. This principle stands in stark contrast to the contemporary agricultural and forestry approach to husbandry which is based on identifying and understanding critical minimum inputs.

The taxa used in these establishments tended to be either propagated "In House", or purchased from small local nurseries. Great care was usually taken to ensure that the plants were in good condition when they arrived at the planting site, and that whenever possible handling was kept to a minimum. The majority of taxa used tended to be plants which were known to do well within the locality, although more tender specimens of "Novelty Value" were also used for special situations.

Today's modern landscapes bare little resemblance to traditional schemes. Sites are frequently prepared under unfavourable conditions using heavy machinery, which denatures the soil and ruins soil structure. In many cases soil texture is adversely modified, soil preparation is inadequate, planting is carried out in poor conditions and subsequent maintenance is reduced to the absolute minimum.

1.2 FACTORS WHICH INFLUENCE ESTABLISHMENT AND GROWTH ON CONTEMPORARY AMENITY SITES

It is difficult to ascertain the main factors behind the success or failure of a plant on any given site. The complexity of the problem can be highlighted by considering the range of interacting site specific factors such as soil compaction, waterlogging, weed competition, lack of nutrients, slope and degree of exposure, that frequently combine to result in failure, whereas any individual factor may be insufficient to cause death (Stoneham and Thoday, 1985).

Failure does not necessarily mean the actual death of a plant, it could simply mean that the specimen has not achieved an acceptable rate of growth, or quality of display. For example, forestry type trees are normally grown commercially with the objective of producing maximum saleable timber in the shortest possible time. However, in an ornamental landscape the same taxa may be classed as failures if they do not accumulate enough carbohydrate for the actuation of flowering or fruit production (Forestry Commission, 1957).

Contemporary landscape sites are often unsuitable for the direct establishment and growth of ornamental taxa. In these circumstances soils have often become denatured and some form of amelioration must be carried out before planting can take place. David Jeffreys (1987) has suggested that the following substrate characteristics are commonly encountered in land restoration, and on many contemporary planting sites :

1) High compaction
2) Low phosphorus or potassium indices
3) Low cation exchange capacity
4) Low nitrogen
5) Waterlogging
6) Slope instability
7) Large soil particle size
8) Presence of pyrite leading to hyperacidity
9) Presence of high concentrations of toxic metal ions.

When sites are affected by one or more of the above soil conditions the rate of establishment and subsequent growth can be seriously reduced. The problems arising from sub-optimal soils can usually be attributed to one of two major causes. These are as follows :

1. Poor soil structure.
2. Unsuitable soil texture.

Soil structure describes how individual particles are held together. In well structured soils the particles bind in such a way as to allow the easy penetration of plant root systems, and the adequate movement of soil air and moisture. Structure, especially of clay-based soils, can be severely damaged by heavy site traffic, or working on a site during adverse weather. When this occurs the soil may become compacted, denatured and even anaerobic, with a subsequent reduction in plant establishment and vigour.

Soil texture, which is the name given to the relative proportion of sand, silt, clay and humified organic matter, in a soil, largely controls the susceptibility of soils to erosion and stability of structure, i.e. the risk of slaking and compaction (Shepherd, 1986). In contemporary landscape practice sites often have their texture drastically modified by the addition of materials such as crushed brick or general building rubble, and when this occurs growing conditions can be seriously affected.

Any model which purports to predict the establishment and growth of decorative taxa must take into consideration a range of soils and the effects that site works can have on them. The University of Bath model allows the assessment of specific soils and sites, and allows predictions to be made after specifying individual characteristics. The model also allows the selection of taxa capable of tolerating sub-optimal conditions.

In addition to site specific factors the ornamental plant modeller must also take into account plant related features. These can be divided into five main areas, i.e. the selection of taxa which are suitable for the planting site, the size of plant material, potential plant hardiness, the overall stock quality, and the subsequent handling and planting of the selected material.

1.2.1 SELECTION OF TAXA WHICH ARE SUITABLE FOR SPECIFIC SOIL, SITE AND CLIMATIC CONDITIONS

One of the most fundamental choices made in any planting scheme is the decision of which taxa to use. If plants are genetically suited to the prevailing conditions the potential for establishment and growth will be high. If, on the other hand, their requirements are incompatible with site conditions, establishment or growth may be poor, and the planting scheme deemed a failure.

Some degree of failure is undoubtedly due to wrong plant selection rather than the inability of the site to support any form of vegetation. For example, the establishment rate of a planting scheme may be lower than expected where taxa are used which are difficult to transplant, e.g. certain Birch species (Capel, 1980). Similarly, taxa may contain genetic traits which make them unacceptable for use under specific site conditions. For example, in dry situations severe drought damage can be frequently observed on the 'Stapehill 20' clone of X Cupressocyparis leylandii (Jobling, 1979), with little or no damage being exhibited by other forms.

The majority of landscape architects and decorative horticulturalists are dependent upon the general nursery stock trade for their supply of planting material. Sometimes unsuitable taxa are dispatched purely because of incorrect labelling. Other problems arise because of the use of inferior clonal selections of otherwise successful taxa; some plants may even be infected with debilitating virus or fungal diseases. The lack of consistency in plant material makes the job of modelling establishment and growth of landscape taxa extremely difficult.

1.2.2 THE SIZE OF PLANTING MATERIAL

The size and form of a specimen can have a considerable influence on its transplanting success rate. It has been found (Binns, 1983) that in general large plants transplant much less successfully than smaller stock. The reason for this is uncertain, Whitcomb (1983) suggests that larger plants have proportionately smaller reserves of carbohydrates used for new root growth than smaller plants. Grace (1987) suggests that it may be due to the problem of maintaining continuity of water movement throughout the plant, and Thoday (1990) suggests that it is linked to post-harvest desiccation of small roots.

It has been recognised for a long time that the use of large planting stock on contemporary landscape sites can result in high rates of failure. This knowledge has prompted authorities who regularly plant large numbers of trees, e.g. the Forestry Commission (Binns, 1980), to recommend that wherever possible small stock should be utilised in amenity planting schemes in preference larger plants.

1.2.3 PLANT HARDINESS

The hardiness of taxa in the general landscape is based on interacting variables, such as the amount of cold a site experiences, plant tolerance of cold as determined by genotype, the degree of exposure, soil moisture content and nutrient levels. The range and complexity of these interacting variables make the modelling of decorative taxa, and more specifically, the responses of members of a clone growing within even a small geographical area, extremely difficult to predict.

An area of concern affecting landscape transplants is that of the variability in "Phenotypic Hardiness". In certain conditions, e.g. container grown stock left unprotected during the winter, or when plants have been encouraged to produce late secondary growth, a temporary reduction in hardiness can occur (Harris, 1983). The use of planting material which has been subjected to these conditions can seriously confound any modelling strategy.

1.2.4 OVERALL STOCK QUALITY

It is almost inevitable that newly transplanted material will be at a disadvantage as compared to plants which have grown in situ, as these are typically seedlings which will have developed their root geometry in association with the inherent soil structure. Transplants should be grown in such a way as to avoid physical damage, whilst maximising their chances of surviving the transplanting process. They should also be in a suitable condition to allow them to exploit to the full, their new growing conditions (Atkinson & Ofori-Asamoah, 1987).

The reasons why transplants are at a disadvantage are complex; they can include the method of propagation, the root to shoot ratio, vigour and juvenility, internal resources, symbiotic associations and freedom from pests and disease (Kendle, 1988). In an attempt to alleviate some of these problems and increase the overall quality of their stock, a number of growers, e.g. Wyevale Nurseries, ~~have~~ have now developed specialist nursery facilities (Gunn, 1989)

1.2.5 STOCK HANDLING AND SUBSEQUENT PLANTING

Experiments have shown that the loss of roots during lifting (Beckjord and Cech, 1980) can have a detrimental effect on establishment and growth. However, when this occurs in conjunction with either rough handling (Tabbush, 1986) or desiccation (Insley, 1979), the problems can become extremely serious. It must also be noted that other factors, such as the degree of exposure after planting (Mullin, 1971 and 1974) and the non-removal of bio-degradable containers (Insley and Patch, 1980) can also seriously affect growth for a number of years after planting.

The genetic variability within much of the readily available planting stock in England and Wales is often substantial and unfortunately undetectable. In many instances plants are growth 'checked' in the nursery by poor management; others cannot achieve their potential because of viral diseases. Lifting and subsequent handling techniques can adversely affect a plants potential, as can the timing and method of planting. To produce an accurate growth model each individual factor affecting growth and establishment must be isolated and categorised in such a way as to enable the prediction of an accurate response to changing circumstances. The complexity of the inter-relationships of growing ornamental taxa in contemporary landscapes, as compared to more traditional sites, increases the variables considerably.

1.3 ATTEMPTS TO PREDICT CROP ESTABLISHMENT AND GROWTH

The quantification which has taken place in horticulturally related disciplines, e.g. meteorology and the soil sciences, coupled with crop behavioural studies in world agriculture and forestry, has provided a large general database of information. Unfortunately, until relatively recently much of this knowledge has been in a form unsuitable, or unavailable, for direct use by horticulturalists.

The development of readily affordable high speed computing power and improved software design, has allowed this knowledge to be stored and manipulated in a more efficient manner than was available in the past. There is now strong evidence (Edwards & Christie, 1981, Daly, 1982/3, Porter, 1985, England, 1985, ICI, 1986, Hope, 1987) to suggest that the computerisation of these data and their subsequent modelling, can aid agronomists to select, establish, monitor, maximise, and predict the growth of plants.

1.3.1 METHODS OF PREDICTING ESTABLISHMENT AND GROWTH

Horticultural models, i.e. computer programs or mathematical equations, which can be used to describe or predict growth, development and establishment responses, can be categorised in several ways. For example, they may be described as either mechanistic, or empirical. Mechanistic models describe the performance of plants in terms of the processes known to underlie growth and development, e.g. hierarchial, or modular biological systems (Thornley, 1976). Empirical models, however, describe plant behaviour based on observations at the whole plant level (Hope 1986a, Worrel, 1987). Both types are essentially simplified systems built up to provide a better understanding of a real situation and the interaction of its main components.

The methodology chosen must allow the systematic analysis of observed responses to various conditions, which in turn will increase our knowledge of plant growth and development. It must also allow the production of simulations consisting of many complex interactions which will ultimately lead to the development of predictive sequences (Hunt, 1982).

Although modelling techniques have been available for decades, the development of many of the current mathematical modelling and programming procedures, which allow the manipulation of complex data, have evolved over a very short period. In fact, new specialist techniques are still being developed and implemented for an ever increasing variety of situations. The major reason for this is the rapid expansion of the micro-computer industry. Without the use of modern computers and peripherals we would still be utilising long established techniques and the depth and variety of modelling as we know it today would not exist.

1.3.2 PREDICTING PERFORMANCE OF SHORT TERM MONOCROPS

The majority of horticultural and agricultural related plant modelling work carried out to date has been aimed at seasonal monocrops (McMennamy, 1984, Sale, 1984, Salter, 1984, Porter, Klepper & Belford, 1986). In these short term situations it is possible to minimise the effects of variables, e.g. genetical variation, which interact to produce the final product. In practice, much of the work has been carried out on a restricted number of soil types and genetically stable cultivars with distinct recognisable modular growth stages (Zadoks, 1983).

When compared to hardy decorative taxa the length of the life cycle of these crops is short, i.e. typically one year, as in cereal production (Holmes, 1984) and field vegetables (Austin 1984). This means that successive crops can be grown and assessed over a relatively short period of time, and that interactive input, such as introducing day by day climate related data is possible.

Another important advantage of this type of modelling is that a recognisable and measurable product is actually produced. This means that modifications in the management of the crop, or the predictive model, can be accurately measured in direct relation to crop yield. In decorative horticulture it is much more difficult to obtain an agreed definition of what the final product should look like.

When producing a known marketable product it is possible to develop predictive models which can highlight features other than direct crop growth. For example, it is possible to develop a model to estimate the total yield of a crop through-out the country, by means of red and infra-red spectral bands (Steven, Biscoe & Jaggard, 1982). Similarly, it is also possible to predict the economic control of weeds in specific crops (Doyle, Cousens & Moss, 1986).

Anything which affects the growing conditions of a short term monocrop will ultimately be reflected in the yield or quality of the crop. A number of models have been developed which calculate the effects of specific site related criteria on both yield and quality, e.g. soil compaction (Wheeler & Audsley, 1980), or cultural techniques, such as modelling the performance of pesticide spray decisions (England, 1985, Cousens, 1987). When utilised correctly this type of model can be of immense economic value to a grower.

1.3.3 PREDICTING PERFORMANCE OF LONG TERM MONOCROPS

It is usually much more difficult to predict a range of specific aspects of growth with "whole-plant" crops which are grown over a protracted period of time, e.g. hardy ornamental taxa and forest trees, than "organ" crops, e.g. cereals, grown in one season. Similar difficulties arise when attempting to predict the growth of whole-plants producing saleable organs, e.g. fruit trees.

The main problem with such predictions is that variations in climate have a marked influence on both seasonal and intra-seasonal growth patterns. Droughts, heavy rainfall and cold periods all affect growth, and when these occur unexpectedly, typical predictive growth and establishment sequences can be severely corrupted.

A number of mainly empirical long season monocrop models, i.e. programs which relate to the plant as a whole, have been developed. The most important ones in financial terms are probably those relating to forestry (Hamilton & Christie, 1973), although others, e.g. for grassland (Daly, 1982) have also proved to be economically useful.

The majority of current short and long term models are based on highly mathematical concepts which have been developed to encompass extremely narrow fields of research. The larger more complex types, e.g. the AFRC Wheat model (Porter, 1983) have been designed in a modular form utilising research from a number of specialist faculties.

1.4 THE PREDICTIVE USE OF MODELS

Many landscape architects would welcome more positive advice on species selection and the subsequent management of their planting schemes. The use of computer models will, in certain circumstances, enhance both management skills and productivity, although if used incorrectly, they can also have a deleterious effect. When the first predictive models, e.g. the "Plant Selector II" programme (Hope, 1981), the UKF Fertiliser's "T•-SUM" (Daly, 1982) and Imperial Chemical Industry's "N - SURE" (Orson, 1986), became readily available they were treated with widespread scepticism. However, all three of these models are now accepted as being useful management tools.

It must be remembered that predictive models are only as good as the base data from which they work, and that people will always question the validity of predictions (WPBS, 1988).

1.4.1 THE IDEAL PREDICTIVE MODEL

In the study of monocrops the major method of development has been to produce individual mechanistic models relating to specific plant or growth characteristics. When each has been formulated they have been merged together to form one large operational system (Porter, 1983). If enough resources were available this method would be ideal to model the establishment and growth of genetically stable individual taxa, however, at the present time there are so many intangibles that such an effort would be unproductive and totally uneconomical. Instead a more simplistic empirical approach has had to be undertaken whereby data relating to soils, climate, planting site and individual taxa have been stored and manipulated in such a form as to aid in the selection of planting material and management techniques for any individual site.

Models may be used to interpolate or extrapolate from existing knowledge about the processes of establishment, growth and development. For predictive purposes they need to be correct mathematical statements of observed or assumed inter-relationships between different plant processes and plant parts. They should be tested for accuracy under precisely defined conditions, and only then should they be used to simulate the effects of different management and site related factors of plant growth.

The ideal establishment and growth model for a wide range of ornamental taxa would have to store and manipulate detailed data on crop physiology, climate, soils, sites, and cultural management techniques. In its most simplistic form it would have to provide a wide range of data relating to individual taxa, whilst being simple to use and available on all micro-computers.

Some of the major features necessary for the development of a successful model are as follows :

1. The inclusion of major contemporary biological concepts about plant growth processes responsive to management, i.e. concepts held by practising plant growth researchers.

2. The development of mathematical procedures which are calculable on a micro-computer.

3. The optimisation of data input, and programme execution time.

4. The exhibition of excellent replication of field behaviour when compared with experimental field trials within the geographic region of concern.

5. The production of well documented instruction manuals, including a biological and computer

system flow chart, and definitions of criteria used.

6. The inclusion of an adequate but not cumbersome range of establishment and growth criteria.

7. The inclusion of a simple procedure for the addition or alteration of criteria.

8. The provision of routines to enable the addition of new user requirements.

9. The development of "User Friendly" menus.

10. The availability of detailed printout.

11. The inclusion of routines to enable links to other models.

12. The development of transportable programme code, i.e. produce programmes usable on more than one type of computer.

Many of the above features, e.g. "User friendliness", would be included in most contemporary models, although others, e.g. execution time, will be continually modified as new techniques and computers are developed.

1.5 MODELLING OF PLANT RELATED CLIMATIC FEATURES

The cultivated flora of the British Isles is very large, but many taxa do not perform satisfactorily in the general landscape. The reason for this can often be accredited to the vagaries of the British climate.

Any model which attempts to predict or quantify the growth or response of taxa used in the general landscape must at some point make reference to climatic criteria. Quantification is necessary to correlate interrelations such as tolerance to low winter temperatures, but also to highlight more subtle interactions such as the effect of localised shading on the vegetative and reproductive phenotype. In contrast to decorative plant users, commercial crop producers have striven to define precisely, the climatic regime in which a crop can or cannot perform satisfactorily (Amerine & Winkler 1944, Bleasdale, 1973, Daly, 1982/3). Similarly, ecologists have also recognised the importance of a classification of climate as an aid to understanding plant behaviour and distribution (White & Lindley, 1976, Vink, 1983).

In the past the major aspect of climatic interaction with horticultural taxa has been the discussion or prediction of low temperature hardiness. The majority of horticultural literature gives some indication to the relative hardiness of a particular taxon, but unfortunately, in most cases the assessment is of a very generalised nature. For example, such phrases as "Not hardy in the north of

England", and "Only hardy on the south coast" are frequently used. Some books tend to give an even more generalised indication, e.g. "Hardy in the British Isles", or "Tender in the British Isles". When the latter type of description is adopted the author will usually be rating hardiness in relation to a specific location, e.g. the Royal Botanic Gardens Kew, and will not usually take into consideration the plant's performance in more northerly climes.

There is also a considerable discrepancy concerning the amount of cold a plant can sustain before it is classed as hardy. For example, some authorities may consider a plant hardy if it is not killed during an average British winter, whereas others may not consider it hardy unless it can survive the type of extreme climatic conditions Britain experiences on average once every ten or twenty years.

Finally, few authors, if any, seem to take into consideration the complexity of the situation resulting from factors interacting. Many climate factors are not directly related to minimum temperatures, yet affect the survival of a plant in a particular location. These factors can be listed as follows :

a. Timing of winter cold.
b. Intensity of winter cold.
c. Duration of winter cold.

d. Interaction of climatic and site conditions.

e. The physiological hardiness potential of the particular plant in question influenced by such factors as, ecotype selection, daylength and temperature during autumn, soil moisture, nutrient regimes and carbohydrate status.

Clearly, there is no consensus, using currently available British decorative plant literature, whereby a definitive concept of such features as hardiness can be formulated (Hitchmough, 1984a). The lack of such concepts severely restrict the production of a climate related model, and tend to act as a barrier to understanding the complex relationships between plant performance and the British climate.

There have been attempts to classify the British climate in relationship to plants, but they have tended to be agricultural, and forestry orientated, and not aimed at the performance of decorative taxa, although work by Fairburn in 1968, White and Lindley in 1976, White in 1977 and 1980, Hitchmough in 1984 and Hope in 1986 have all been of considerable use in the formulation of the University of Bath assessment model.

In other countries, notably the United Sates of

America, climatic classifications in relation to decorative plant performance have been produced. For example, A. Rehder formulated a relatively sophisticated system in 1951. Unfortunately, he ignored from his work the relationship of micro-climatic modifying influences, and altitude.

Any computer model will be confounded by the complexity of climate/ornamental plant interacting factors, although in practice, because of the dearth of detailed data, the problem does not arise.

The University of Bath assessment model highlights the deficiency of contemporary knowledge. In doing so it has attempted to firstly, identify and then incorporate macro and micro-climatic parameters relevant to decorative taxa performance. Secondly, it has attempted to enable the prediction of values for these parameters, irrespective of altitude, and relate them to decorative plant performance in terms of the minimum values necessary to establish and sustain a satisfactory specimen.

1.5.1 CLIMATIC DATA USED IN THIS MODEL

Most of the meteorological data used in the assessment model have been derived from the Ministry of Agriculture Fisheries and Food Bulletin number 35. This was originally compiled by L.P. Smith, and first published in 1976, with a re-issue in 1984 as Reference Book number 435. The title of the publication is "The Agricultural Climate of England and Wales", and it contains meteorological data relating to areal averages for the years of 1941 to 1970 inclusive. Unfortunately, Smith's work did not include data relating to Scotland, and so this area had to be totally omitted from the assessment model.

Smith, in consultation with ADAS, sub-divided mainland England and Wales into 67 zones with broad similarities of farming type. However, he also included the Isles of Scilly, the Isle of Wight, the Isle of Man and the Channel Islands, making a total of 71 "climatic" zones. The University of Bath assessment model encompasses 70 of these zones; the Channel Islands being omitted due to lack of sufficient data.

The data contained in Bulletin number 35 have been used by previous authors (Hitchmough, 1984a, Hope 1986a) to predict climate related growth responses in decorative horticultural taxa, e.g. plant hardiness. This work showed that climatological data could be a useful tool in horticultural predictive models.

Although the climatic aspects of the assessment model are largely based upon Bulletin number 35 and Technical Reference book 435, it also utilises information from other sources, e.g. the Soil Survey of England and Wales, Technical Monograph Number 15, (Bendelow & Hartnup, 1980) and The Institute of

Terrestrial Ecology (White & Lindley, 1976, White 1977, White 1980).

1.6 MODELLING THE ESTABLISHMENT AND GROWTH OF ORNAMENTAL TAXA

The modelling of the establishment and subsequent growth of hardy perennial ornamental taxa is an extremely complex issue. It has been shown that planting initiatives, e.g. the "Plant a Tree in 1973" scheme, can lead to failure rates within four years of 70% or more (Lisney, 1983). This figure does appear somewhat excessive and it may have been affected by poor initial planning of the campaign and an overburdening of the plant supply infra-structure. Other work (Skinner, 1986) has shown that although the general fatality rate is unacceptably high, a more realistic survival figure would be approximately 54%, and Insley (1982) suggests that plant loss is closer to 30%. Even when plants do become established in the first year, they frequently under perform and in certain circumstances decline in stature and eventually die (Gilbertson and Bradshaw, 1985).

The University of Bath assessment model has been developed to enable the user to identify potential problems associated with the interrelationship of climate, sites and ornamental taxa. One aim of the model is to help raise the success rate of transplants on contemporary landscape sites.

1.6.1 TAXON RELATED DATA USED IN THIS MODEL

The problems associated with the quantification of data related to specific decorative taxa have been recognised for a number of years, although it is only really since the advent of micro-computers and the development of sophisticated plant retrieval databases (Hitchmough, 1984a, Sinclair, 1985, Hope 1986a) that the deficiencies have been seriously highlighted.

Before taxon related information can be used in any computerised system, it must be collated from several sources and finally assembled into a usable form. The difficulties involved with this process have been well documented, e.g. in James Hitchmough's and Frank Hope's previous research, however, it is of such fundamental importance that it must be highlighted once more.

1.6.2 WEAKNESSES APPARENT IN CONTEMPORARY LITERATURE

The major traditional British source of decorative plant information for those concerned with plant cultivation is standard botanical and horticultural reference books, such as :

> Trees and shrubs Hardy in the British Isles.
> (W.J. Bean. 1973-80 Volumes I-IV 8th Edition).
> John Murray, London.

The Royal Horticultural Society's Dictionary of Gardening.

(F.J. Chittenden. 1956 Volumes I-IV 2nd Edition + supplement. Oxford University press).

In addition to the above, more popular works, such as "Hilliers Manual of Trees and Shrubs" and DR. D.G. Hessayon's "The Tree and Shrub Expert" are often consulted, as are specific plant monographs. Plantsmen, herbaria, plant reference collections and domestic gardens are also invaluable sources of information.

There is undeniably an extensive literature relating to decorative taxa, some of which is authoritative. It should be recognised, however, that this literature has many deficiencies, when related to plants growing outside the garden, public park or botanical collection.

The major deficiencies of contemporary horticultural literature in relation to computerised modelling are that the majority of books are aimed at the amateur, there appears to be a random inclusion of information, some of the information is ambiguous, and in certain instances, some of it is incorrect (Hope, 1986b).

The University of Bath assessment model holds data relating to taxa which are currently frequently planted in the general landscape as well as in more traditional locations, such as botanic gardens, public parks, and private collections. The system contains data, some of which have never before been systematically collated, and because of this some of the basic concepts may at first seem divergent to standard practice.

The assessment model contains two fundamental databases of plants. The first contains a list of 1,000 taxa which are susceptible to damage from low temperatures (Appendix C, volume II), whilst the second consists of intolerance data relating to all entries in the Joint Council of Landscape Industries (JCLI, 1978) Plant list (Appendix D, volume II).

The "tender" plant file has largely been based on survey derived hardiness ratings for plants considered susceptible to damage in a ten year extreme winter (Hitchmough, 1984b), although the JCLI plant list and a range of horticultural literature were also consulted. The final database consists of a simple list of latin names; no other data are held in the file. The actual method of assessing the hardiness potential of the taxa is carried out mathematically within the model using site and climate related criteria.

The "intolerance" file holds data on the following soil, site, and climatic features :

a. Soil Texture

b. Soil Depth

c. Soil Moisture

d. Soil pH

e. Maritime conditions

f. Exposure

g. Late spring frosts

h. Seasonal water-logging.

The plant entries contain a numeric rating for each of the above listed intolerances (see Appendix D. volume II). When the assessment model is run and a plant is selected, the programme checks the plant's intolerance ratings against the specific site's soil and climatic conditions; a warning is given if any potential intolerances are suspected.

Much of the available contemporary horticultural literature does not contain definitive data relating to the above intolerances. This has meant that to compile suitable data the author has had to utilise other literature, consult horticulturalists, search computerised plant retrieval databases, and use his own broad horticultural experience. Unfortunately, this means that much of the data stored are, by necessity, subjective, and until a more rationalised approach to identifying and cataloguing plant data exists, this situation will remain.

1.7 MODELLING SOIL AND SITE RELATED FEATURES

Traditional horticulturalists aim to create ideal conditions for establishment and growth. Management is targeted at producing well drained, structured soils with adequate nutrient reserves, whilst adverse site conditions, such as exposure to strong winds, are alleviated to encourage a stable, sheltered micro-climate. Contemporary landscapers' on the other hand, frequently inherit inhospitable soils and surroundings, which are inconducive to healthy plant development.

The range of potential problems found on contemporary landscape sites is extensive. Sites may be in exposed locations, they may contain denatured or compacted soils, the topsoil may have been removed and not replaced, the soil may contain harmful chemical contaminants, and in certain cases, e.g. reclaimed waste tips, harmful gases such as methane may be present.

The development of a realistic soil and site related model for use with traditional horticultural techniques would be an extremely difficult task to achieve. However, when the complexities and interrelationships of contemporary sites are also considered, the problems, at the present time, become insurmountable.

The University of Bath assessment model makes no attempt to predict plant growth responses in relation to a range of sites and soils in the contemporary landscape. Instead, a more simplistic approach has been followed which highlights potential problems and generates a series of descriptive notes explaining how the problems can be alleviated. In addition, the model also identifies taxa which are intolerant of a range of specific soil and site conditions (see 1.6.2).

1.7.1 SOIL AND SITE RELATED DATA USED IN THIS MODEL

The Soil Survey of England and Wales classify soils by means of observable or measurable characteristics of the soil profile (Avery, 1980). For this purpose a profile is considered to be a sample of the soil mantle extending from the ground surface to approximately 1.50m, and formed of several soil horizons.

The information relating to individual soil profiles is outlined by the use of 6, 1:250,000 scale maps covering the whole of England and Wales, and a legend which describes the detail of the maps (Lawes, 1983). The legend gives details of constituent soil associations, although more information can be obtained from the Rationalised Classification of Soil Series (Clayden & Hollis, 1984).

The assessment model holds all the data contained in the 1:250,000 map legend, but in addition, further detailed information on specific aspects of soils and sites, has been derived from a wide range of other works. For example, exposure ratings, thermal regions and moisture regimes have been compiled from the Soil Survey's Bioclimatic Classification maps (Lawes, 1978), soil textural data have been extracted from ADAS publications (Advisor, 1986) and irrigation data have been extracted from the HMSO Reference Book number 138 (HMSO, 1982).

2.0 THE DEVELOPMENT OF COMPUTER DATA STORAGE TECHNIQUES

In 1946 the first electronic computer, designed by Professors Eckert and Mauchley of the University of Pennsylvania, and named ENIAC, became operational. This machine was originally developed for the United States Defence department and was primarily concerned with highly complex mathematical computations, with little requirement for rapid mass storage of data. It took a further 5 years after the introduction of ENIAC before the first Magnetic tape storage system was introduced (Rosen 1969).

Magnetic tape had a revolutionary effect on data storage; it was light, reliable, enabled mass storage and when compared to card files was extremely fast. One of its main failings, however, was that data had to be read sequentially (Knuth, 1971-83), i.e. to access a record it was necessary to scan all intervening records.

Computer development continued relatively slowly throughout the 1950's and early 1960's, although in the mid 1960's magnetic discs were introduced which allowed random access of data (Gottfried, 1975), i.e. going straight to the required data by by-passing unwanted records. This gave a dramatic increase in retrieval speed, and a more flexible system of data management.

In the last fifteen years the use of computers to store and manipulate data of various and contrasting kinds, e.g. vehicle registration records, has increased dramatically (Hampshire, 1990). One of the major factors behind this expansion has been the development of sophisticated silicon chips, with the subsequent introduction of relatively cheap microprocessors, e.g. the INTEL 80486, and the more expensive "State of the Art" processors, such as the INTEL i860 (Pountain, 1989).

The use of micro-computers in industry and commerce is now widespread, although decorative horticulturalists appear to be extremely slow to appreciate their value. In many instances, computers are still only used for simple repetitive tasks, such as label printing, and general stock control.

In the past, the major use of computers in decorative horticulture has been almost entirely confined to database management systems, such as botanical and Tree inventories (Hunt 1978, Morris, 1980, Bickmore and Hall, 1983). However, more recently a general interest in the computerisation of decorative plant information and computer aided design techniques (Barr, Krimper, Lazear and Stammen, 1985. Sawyer, 1989) has lead to an upsurge in interest, especially in disciplines such as Landscape Architecture.

3.0 THE DEVELOPMENT OF A COMPUTER MODEL

There are two basic methods available for the development and subsequent production of a complex computer model. Firstly, it is possible to use a commercially available database or spreadsheet system. Secondly, the modeller can produce a "Dedicated Program" by writing the computer code himself. Both methods have major advantages and disadvantages, and the route chosen will ultimately be selected by the modeller's personal preference.

3.1 DATABASE MANAGEMENT

Database retrieval systems are actually complex computer programmes which can handle the storage allocation, retrieval and updating of information (data). S. M. Deen (1985) defined them as :

"A generalised integrated collection of data together with its description, which is managed in such a way that it can fulfil the differing needs of its users".

There are a number of commercially available, database management systems, for example, Dbase IV (Ashton Tate, 1989) and DataEase V4.0 (Swarbrick, 1989). The features which each contain and the quality of the documentation, are often commensurate with their price.

In addition to general database management systems the so-called "Integrated Packages", such as Lotus 1-2-3 (Lotus Inc, 1982) and Symphony (Lotus Inc, 1983), have been developed and made commercially available. These enable the user to have the facility of database management, with spreadsheet and high resolution graphics capability.

The availability of a spreadsheet, i.e. a specialised computer program designed to carry out complex mathematical calculations, is especially useful for highly theoretical models.

General database management systems and Integrated Packages are designed for use in the general computing environment, which means that when set up to perform computer modelling problems, or for other specialised uses, they will contain many unnecessary and unused features. This generality of structure, although an advantage in many applications, also means that the storage of data, and subsequent searching and manipulation will often be inefficient when compared to "Dedicated Systems".

The majority of the current commercially available database packages are complex and difficult to use. Most professional packages contain a "Procedural Language", i.e. a programming language which is built into the database and which is structured in terms of the procedures the system must follow in order to carry out a task. Before a database programme containing one of these procedural languages can be used efficiently the specific procedural language must be mastered.

As an aid to database development "Database Generators/compilers", for example "Clipper" (.EXE, 1989) designed for use with the notoriously slow Dbase IV, have been produced which automatically set up databases to suit various user criteria. These programmes are costly, but negate the pre-requisite of learning the specific database procedural language. Clipper type programs are useful for generating code for inexperienced users, and they are often claimed to increase the speed of execution. However, in many cases no apparent increase in speed results and in certain circumstances an actual reduction in speed can occur (Greenwood, 1988).

It is possible to develop an assessment model utilising one, or a combination of the above mentioned types of programme (Hitchmough, 1984a). However, when compared to dedicated programmes any such system would normally be sub-optimal in both the method of data storage and the speed of mathematical computations. However, it must be stated that the speed of computations can be increased by the incorporation of a specialised mathematical micro-chip, e.g. the INTEL 80287. To avoid copyright infringement on remote micro-computers, the use of commercially available database programmes would also require that each potential user purchase the basic database programme before the model could be used (Clifton, 1986), or they would have to enter into some form of licensing agreement.

3.2 DEDICATED MODELS

The development of "Dedicated models" allows the programmer total flexibility in design. Each part can be maximised for speed, data storage, User Friendliness and portability. The "Source Code", i.e. the actual program will only contain routines and algorithms necessary to allow the functioning of the model, which in turn minimises the size of the program. Unlike commercial database programs, no royalty payment should be necessary before other people can use the model.

When micro-computers first became available storage was of paramount importance, but with the decreasing cost and increased capacity of storage devices, e.g. Optical discs and CD Roms (P.C. Week, 1988a), it is now looked upon as being far less critical. Instead, todays programmers tend to focus their attention on points such as speed of operation, readability, program maintenance and reliability. To produce models exhibiting these characteristics a detailed planned approach must be followed.

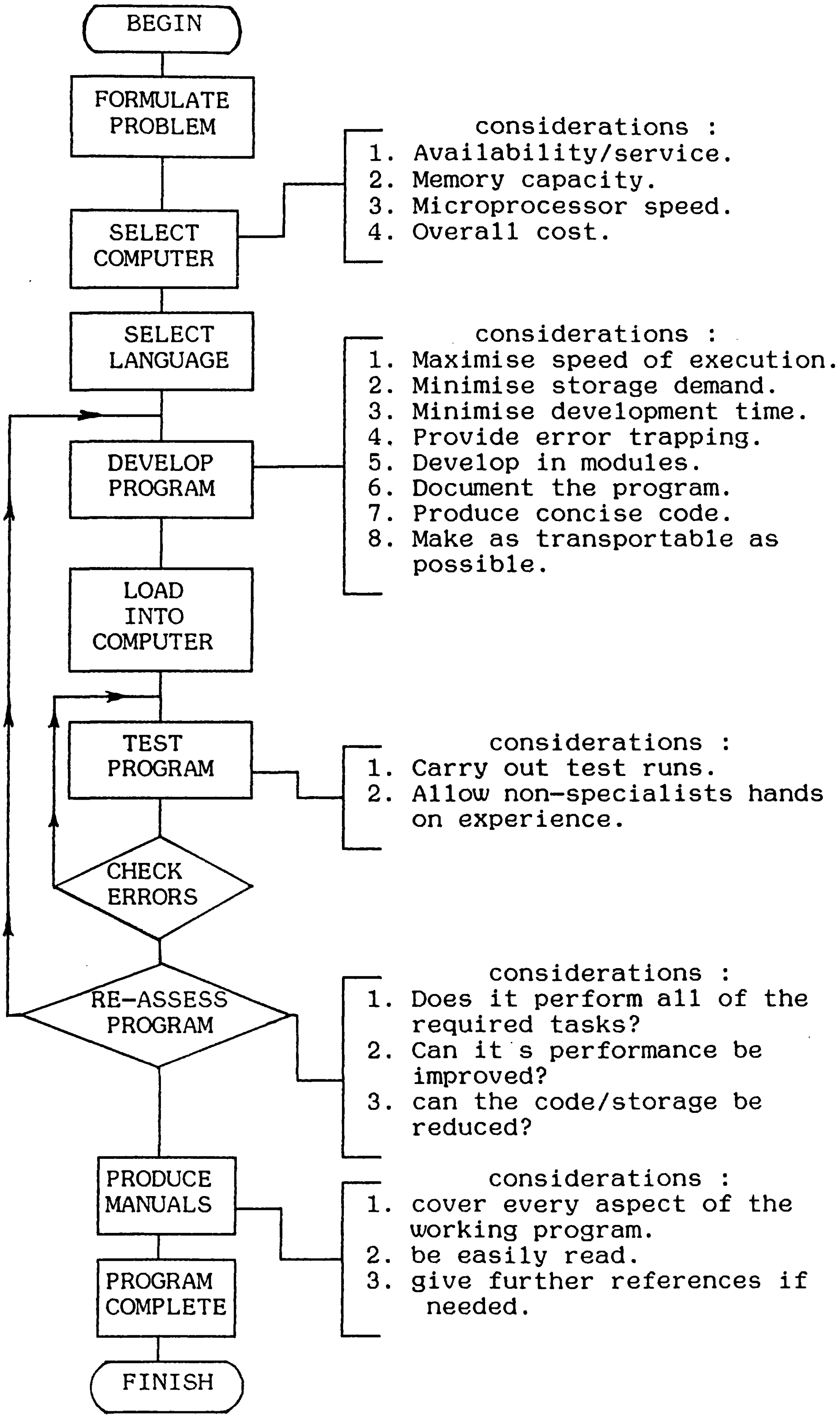
As with the University of Bath micro-computer based retrieval system (Hope, 1986a), the University of Bath assessment model has been developed using an approach known as "Top-Down" programming, or "Hierarchial Modularity" (Guttmann, 1977).

Top-down programming means that the overall problem is broken down into a number of distinct, highly-abstracted processes which are to be performed successively (see Fig. 2). Each process is then considered individually and is again broken down into less-abstract processes, i.e. developed in a sequence of steps, each of successively finer detail. This dissection of the overall problem continues until each individual process is small enough to be directly translated into a programming language.

3.3 IDENTIFYING THE PROBLEM TO BE SOLVED

Identifying the problem to be solved means isolating various problem areas and producing an overall plan of events. It can be accomplished in a number of ways. When a programming task is of relatively minor complexity some programmers ignore the planning phase altogether and begin programming immediately. Others always carry out some pre-planning activity, but vary the amount depending upon the complexity of the programming task. The university of Bath micro-computer assessment model is highly complex and required a large amount of pre-planning.

Figure 2. Example of TOP-DOWN programme approach.



4.0 DETAIL OF THE ASSESSMENT MODEL DEVELOPMENT

a. Produce 3 programmes :

1. Introduction.
2. Assessment model.
3. Data entry/modification.

b. Make all the programmes menu driven, i.e. allow the selection of options via menus (lists of alternatives).

c. Display adequate prompt messages whenever necessary.

d. Have a series of error trapping routines to prevent incorrect operator input/mistakes.

e. Encode adequate escape sequences to enable the user to cancel operations without modifying, or corrupting existing data.

f. Provide an efficient, quick method to move from one programme to another.

g. Produce easily read and attractive display screens.

h. Produce adequate documentation.

4.1 INTRODUCTION PROGRAMME (MAIN MENU)

General outline :

a. Display the title of the research project, the author's name and address, and the address of the University of Bath.

b. Display a copyright notice.

c. Allow the selection of either one of the following programme options :

1. Enter the Assessment model.
2. Enter the data input/modification programme.
3. Return to the system prompt (DOS).

d. Display a prompt message outlining the method of selection.

4.2 PLANT ASSESSMENT MODEL

This is the longest and most complex of the assessment programs. In the formulation phase it was planned in three distinct sections, namely, location/climate related parameters, soil/site related parameters and taxon related selection.

A. CLIMATE RELATED PARAMETERS

General outline :

a. Store climate related information on disc relating to 70 climatic zones covering England and Wales. The data to be stored relating to :

1. Town/city.
2. Reference point of site location.

b. Allow an automatic log-on sequence to enable the user to select information relating to a pre-recorded town, or city without affecting any pre-recorded data. Also allow the log-on data to be modified whenever necessary.

c. Display a map of England and Wales highlighting the location of the selected town/city.

d. Display, within the area of the map, the following site related data :

1. Area zone.
2. Height range within the zone.
3. Average height of the zone.
4. Height modification rating.
5. Mean Latitude of the zone.
6. Coastal rating.
7. Exposure rating.

e. Allow the use of correction factors relating to micro-climatic variations, e.g. altitude levels, coastal proximity and exposure.

f. Automatically calculate all climatic criteria incorporating any micro-climatic adjustments.

g. Display, in histogram form, data relating to the following 16 climatic features :

1. Air temperatures.
2. Earth temperatures.
3. Rainfall.
4. Potential transpiration.

5. Sunlight.
6. Daylength.
7. Solar radiation.
8. Illumination.
9. Degree days above 10 degrees centigrade.
10. Effective transpiration.
11. Last expected spring frost.
12. Degree days below 0 degrees centigrade.
13. Summer soil moisture deficits.
14. Date of return to field capacity.
15. Date of the end of soil field capacity.
16. Excess winter rain.

i. Allow the selection of a second location, and display climatic information for both sites.

j. Highlight the growing and dormant seasons, in pie-chart form, for the mean of the country and each selected location.

k. Display a series of "HELP" notes indicating the selection of program features.

l. Display adequate prompt messages, and indicate the use of specially defined keyboard keys.

m. Allow the user to return to the introduction programme.

The location and climate related phase of the program was designed to enable the calculation of climatic ratings for specific sites within the 70 zones of England and Wales. Having calculated the initial ratings the user is then allowed the option of modifying them to suit his own site.

B. SOIL AND SITE RELATED PARAMETERS

The general program design was based upon the selection and modification of a wide range of site and soil related features, each of which can have an affect on the establishment and subsequent growth of ornamental taxa.

General Outline :

a. Select any of the following site and soil related features :

1. Soil textural group.
2. Soil depth.
3. Soil drainage characteristics.
4. Groundwater effect.
5. Slope.
6. Possibility of erosion.
7. Soil structure.
8. Presence of soil pans.
9. pH rating.
10. Organic matter content.
11. Calcium carbonate content.
12. Soil nutrient status.
13. Provision of artificial protection.
14. Degree of weed control.
15. Provision of artificial irrigation.

b. Allow the modification of any of the above features.

c. Allow the selection and display of the Soil Survey of England and Wales data under the following headings :

   1. Map/sub group.
   2. Soil association.
   3. Soil map symbol.
   4. Soil map symbol number.
   5. Ancillary sub-groups and series.
   6. Geology.
   7. Soil/site characteristics.
   8. Cropping and land use.
   9. Total area of the series in square kilometres.

d. Print a series of notes highlighting specific features of the site, e.g. recommendations for applications of fertilisers.

e. Display a series of "HELP" notes indicating the selection of program features.

f. Display adequate prompt messages, and indicate the use of specially defined keyboard keys.

g. Allow the user to return to the introduction programme.

C. TAXON RELATED FEATURES

General Outline :

a. Compile a list of approximately 1,000 taxa which are potentially susceptible to damage by frost.

b. Compile data relating to all taxa listed in the Joint Council of Landscape Industries "Plant list of Trees, shrubs and conifers", prior to 1988.

c. Calculate a hardiness rating for all pre-recorded taxa.

d. Display information relating to the following plant intolerances :

1. Soil texture.
2. Soil depth.
3. Soil moisture.
4. Soil pH.
5. Maritime conditions.
6. Site exposure.
7. Susceptibility to late spring frosts.
8. Intolerance to seasonal waterlogging.

e. Display a series of "HELP" notes indicating the selection of program features.

f. Display adequate prompt messages, and indicate the use of specially defined keyboard keys.

g. Allow multiple searches and assessment to be made without the necessity of re-typing the taxon name each time.

h. Allow the user to return to the introduction programme.

Once a location has been selected the user should be at liberty to make a series of modifications relating to the specific climate, soil and site. It should then be possible to assess taxa for use in that location.

4.3 DATA INPUT/MODIFICATION

All the pre-recorded data relating to the assessment model has been either stored in data-files on disc, or directly built into the actual programmes. Two basic data types exist, i.e. permanent reference data which are never modified, e.g. zonal climatic data, and semi-permanent (transient) data, e.g. taxon names and their corresponding intolerance attributes, which can be modified at will.

A major part of any assessment model must be the production of an input/modification programme which is easy to use whilst being capable of controlling and storing each type of data. An outline for the formulation phase of the assessment model is as follows.

General outline :

a. Display a new screen containing a list of available options, i.e. a "MENU", and adequate prompt messages.

b. Allow the selection of each option.

c. Enable the user to enter the following types of input :

   1. Initiate a completely new set of data-files. This entails allocating the correct amount of storage space and zeroing the relevant input fields, i.e. set every attribute to initially equal zero (0).

   2. Enter new climatic, site, soil and taxon related data.

   3. Allow the modification of climatic, site, soil and taxon related data.

d. Design an input routine capable of handling numeric, character and alpha-numeric data. The routine should also be capable of controlling the amount of data entered into each input field.

e. Allow the user to locate data by using a key identifier, e.g. a taxon name.

f. Design a routine to enable the user to locate and subsequently display a town/city on a map of

England and Wales.

g. Allow the user to cancel input and return to the introduction programme.

5.0 THE COPYING OF PROGRAMMES AND DATA

The use of computer systems to store and manipulate data can be very beneficial in both time and labour. The data are usually stored on media such as magnetic tape, floppy discs, or Hard discs (Winchesters) all of which can be prone to loss of data via external factors, e.g. power failures/fluctuations and physical damage. It is because of the possibility of accidental data loss, or in some instances programme loss, that some form of back-up system must be devised. The word back-up in this context means the copying of data and programmes onto new media. In certain circumstances it may be beneficial to prevent the copying of programmes, but the facility to copy transient data is usually critical.

The University of Bath assessment model has no specially prepared back-up routine. Instead copies of the programmes and data-files can be produced by utilising the MS-DOS (Microsoft, 1987a) "Diskcopy", "Copy" and "Backup" utilities supplied with individual computers. Where regular copies are necessary a "Batch-file", containing a sequence of backup commands would be adequate for most circumstances.

6.0 THE SELECTION OF COMPUTER HARDWARE

In the mid 1970's when the first micro-computers became readily available they were based on 8-bit technology. This was typified by the Zilog Corporation's Z-80 microprocessor as found in the Tandy TRS-80 micro-computer, and the 6502 microprocessor, as used in the Apple and Commodore Pet (Freeman, 1983).

The term 8-bit technology refers to the method in which data is handled (Barden, 1980). In these machines the data is processed 8 bits at a time, or in 1 byte segments (8 bits = 1 byte) and in most 8-bit micro-computers there is an upper limit of 65,536 8-bit memory locations.

In 1978 the Intel Corporation of America introduced the 8086 microprocessor, and the year after a modified version known as the 8088 (Morse, 1982). The 8086 is a 16 bit microprocessor, i.e. it processes data 16 bits at a time and has over 1 million memory addressable locations. The 8088 version has the same basic architecture as the 8086, but is essentially an 8-bit system that uses a 16-bit microprocessor (Coffron, 1983).

In 1982 ACT (Uk) Ltd, now Apricot Computers Ltd, started to import into Britain from America, the first micro-computer using the 8088 microprocessor, i.e. 16-bit technology. The machine, manufactured by Sirius Systems Technology Inc, of California, was called the ACT Sirius 1, and two models were initially imported.

The ACT Sirius range initially lead the field in the British 16-bit micro-computer market, but within two years Apricot computers Ltd, had produced their own models utilising the successful 8088 architecture. These machines, given the name APRICOT, where totally compatible with the ACT Sirius, and made Apricot Computers Ltd, the leading professional micro-computer manufacturer/distributor in Britain.

In 1982 Acorn Computers in conjunction with the British Broadcasting Corporation (BBC) introduced two 8-bit machines known as the BBC model A, and BBC model B. Both incorporated the 6502A microprocessor (Freeman, 1983) as their central processing unit, but had the facility to utilise others, for example, the Zilog Z-80 could be added as a second processor. The marketing of the BBC computers was initially aimed at educational and hobbyist sectors, not the professional computer market.

In 1983 the International Business Machines Corporation (IBM), the worlds largest mainframe computer manufacturer, entered the American micro-computer market with a model known as the IBM-PC. It was designed with the Intel 8088 as the central microprocessor, but cost considerably more money than the Sirius and Apricot machines, and it was a relatively long time before the machine was officially introduced into this country.

Apple (US) Ltd, also released a micro-computer called the Macintosh, which was based on the same 32-bit architecture of their larger, more expensive "Lisa" machine. On its release the Macintosh was hailed as the harbinger of modern computer design, but unfortunately it was also severely criticised for many hardware and software deficiencies. A redesigned version of the Macintosh has since been released which is a considerable improvement on the original (Walker, 1986).

Since IBM entered the micro-computer market it has become the dominant force. The majority of manufacturers have produced IBM compatible machines, with only a limited number of companies, e.g. Apple (US) Ltd, having a customer base willing to accept non-IBM compatibility.

The original IBM-PC specification was openly "cloned" by many other manufacturers which has prompted IBM to introduce a new standard design called the "PS/2", based around their proprietary Micro-Channel Architecture (MCA) expansion bus. Having produced the specification IBM will now only allow manufacturers to produce machines under licence (Jackson, 1989), and before licences are granted IBM have demanded royalty payments on all sales of original PC clone machines.

The IBM royalty payment demands have prompted a group of clone manufacturers, led by Compaq, to introduce their own expansion bus specification, i.e. the Extended Industry Standard Architecture (EISA). They hope that this will help to break the dominance of IBM in the micro-computer market.

The introduction of the IBM PS/2 range appears to have stifled overall computer hardware development; the notable exception to this being the Acorn "Archimedes" (Cain, 1989) based on the Inmos "Transputer" (Spicer, 1989).

The development of micro-processor technology has continued unabated through-out the past decade. State of the art processors, such as the new and expensive Intel i860 (Pountain, 1989) are extremely fast, e.g. 33MHz, and can directly address a massive 4 Gigabytes of memory. However, at the present time the majority of new micro-computers are still based around the Intel 80286 and 80386 processors, although the Intel 80486 is beginning to become more readily available.

At the beginning of the current University of Bath assessment model project (October 1987) it was necessary to select a micro-computer, or range of computers which would be suitable to carry out the necessary work. At that time, micro-computer design was in the forefront of public interest. Technology which was available in the early 1980's had become out of date, and the cost of mass storage had tumbled. It was estimated that the selected machine would only have a lifespan of approximately 4-5 years before it became out of date. It was, therefore, important that the assessment model should be developed on a machine which would be compatible with later generation computers. The rapid development of computer technology makes it almost impossible to predict the type of equipment which will be available in 5 years time. Previous computer models (Hitchmough, 1984a, Hope 1986a) have highlighted the incompatibility problems which can occur.

In 1987 International Business Machines (IBM) lead the British micro-computer industry with their Intel 80286 and 80386 range of computers. Their designs were "State of the Art" and all their machines were compatible. Apple computers tended to ignore other manufacturers in relation to computer design and compatibility and their Macintosh machine was being aimed primarily at the desktop publishing market. Acorn computers had a popular micro-computer in their "Archimedes", but as with its predecessor, it was aimed primarily at the education market.

It was decided that the University of Bath assessment model should be based on the IBM compatible Victor V286C (Victor, 1987) micro-computer running MS-DOS 3.3 (Microsoft, 1987a). The actual machine chosen had a standard 640k of Random Access Memory (RAM), a single high capacity disc drive and an internal 30 megabyte hard disc. Hard copy, i.e. printout, was to be provided via an NEC Pinwriter P6 Plus dot matrix printer (NEC, 1988), and the Visual Display unit was to be a Victor EGA high resolution monitor.

The selection of the Victor V286C meant that the assessment model would run on the whole of the Victor range, as well as all IBM 80286 and 80386 compatible machines.

7.0 THE SELECTION OF A COMPUTER LANGUAGE

Traditionally, mainframe computers have had a range of programming languages, e.g. COBOL, FORTRAN and PASCAL, which have specific advantages in relation to individual programming needs. For example, Fortran and Algol are both excellent for use with numerical and scientific problems. The micro-computer industry, however, is rather different. With these smaller machines the norm in the past has been for computer manufacturers to supply one language, usually a version of BASIC (Beginners' All Purpose Symbolic Instruction Code), and either allow third party software producers to supply other languages, or to supply them themselves as optional extras.

The implementations and quality of third party, or optional languages, often vary according to price and whether the micro-computer is directed at the professional, or amateur markets. For example, there are a number of "C" language compilers available on micro-computers. Some, such as "Zortech C" version 3 (Zortech, 1988) developed for IBM compatible computers are supposedly full implementations (Kernighan and Ritchie, 1978), whereas others, e.g. "Borland C" (Borland, 1988) developed for the same machines, are arguably merely subsets of the Kernighan and Ritchie standard.

Computer language development is an on-going process; new features are often added, whilst others become redundant. This makes it extremely difficult to compare the relative advantages and disadvantages of two or more implementations of the same language, and almost impossible to compare different languages. The computer industry has attempted to quantify the standard structure of a number of languages, e.g. the proposed ANSI system (Schildt, 1987) re-defines the "C" language. However, it will be a considerable length of time before full agreement on the structure of all popular languages can be agreed upon.

When developing a programme on a micro-computer it is often desirable to produce the "Source Code" (Gottfried, 1975) in the most transportable form, i.e. write the programme in a language which will run on various makes of computer and can be moved from one machine to another with the minimum of re-programming.

A number of languages, e.g. "C" and Microsoft BASIC, are available on a wide range of micro-computers, and except for minor differences between one version and another these languages are relatively machine-independent. Programmes written in them will normally run on a range of machines with little alteration to the source code. A caveat must, however, be mentioned. Most micro-computers have very specific screen (display) and memory handling functions which vary considerably from one machine to another. Where programmes are developed with extensive intricate screen displays, or were specific memory manipulation is used, programmes will almost certainly require major modifications to the source code before they will run on other machines.

In the past software/hardware incompatibility problems have been extremely commonplace. However, with new programming techniques such as Soft-Cloning (Exe, 1986) which allow programmes written on one machine to run unaltered on others, the problems of incompatibility are becoming less important.

The choice of computer language for any programming need will usually depend upon the knowledge and skill of the programmer, and the availability of the language. In many cases the problem of language selection will be solved purely because the programmer will either prefer to write in a specific language, or may only be proficient in a solitary language.

Almost all major programming languages are available for use on the Victor V286C, but only VBASICA (Victor, 1986) running under MS-DOS 3.3 (Microsoft, 1987a) is supplied as standard. MS-DOS is a standard disk operating system (DOS) which is supplied as software with the Victor V286C computer.

In 1987 when the current University of Bath assessment model project began, it was necessary to select a suitable computer language. At that time "C" was being heralded as the language of the future; especially for use by professional and systems programmers. By 1988 "C" had indeed become one of the major systems languages (P.C. Week, 1988b). However, certain language manufacturers, e.g. Microsoft, recognise the difficulties of using "C" and are now intending to use BASIC instead (Computer Shopper, 1989).

Zortech "C" version 2 (Zorland, 1986b) running under MS-DOS was selected as the programming language for the development of the University of Bath assessment model, and the Zorland Graphics Toolkit (Zorland, 1986a) was used to provide the high resolution graphic primitives, i.e. routines enabling the development of high quality graphical displays. The "C" language was chosen because it was rapidly becoming the industry standard, and it was felt that anyone wishing to modify the model would, in time, be capable of programming in "C". In hindsight this was a mistake as most amateur programmers and many professionals still prefer BASIC.

The University of Bath assessment model is a complex suite of programmes designed in a modular form. During the development phase techniques and algorithms, many of which to the authors knowledge have never been documented, were designed, tested and embodied into the programmes.

Having produced an initial assessment model and having solved many of the programming problems, it would be a relatively simple operation to re-code the programmes into a more high-level interactive language such as BASIC.

8.0 THE DEVELOPMENT OF THE ACTUAL PROGRAMMES.

After formulating the basic design criteria relating to an assessment model, and having chosen a suitable computer and language, the next operation to be carried out is the actual development of the programmes. This can be performed in a number of ways, but whichever method is selected a number of trade-offs (Rosenfelder, 1981) must be considered. The available resources must be balanced so as to arrive at the best overall solution, but each resource can only be maximised at the expense of one or more of the others.

In many cases more than one method can be used to solve a problem, but each programming technique has its own inherent advantages and disadvantages, which means that each must be closely evaluated before being included as part of the programme source code. The evaluation of available resources and programming techniques can be carried out using the following major topics.

a. Efficient use of memory and storage devices.
b. Programme execution speed.
c. The time taken to complete the programming.
d. The usefulness of the finished programmes.
e. Reliability of the hardware and programmes.
f. The ease of maintaining the programmes.
g. Overall attractiveness of the programmes.
h. Documentation of the hardware and programmes.

8.1 EFFICIENT USE OF MEMORY AND STORAGE DEVICES

The efficient use of available internal memory (RAM) and disk storage is an essential consideration when designing any micro-computer programme. Until the advent of 16-Bit machines the typical maximum amount of available RAM memory of a micro-computer was approximately 64,000 bytes (64k). Now, with state of the art microprocessor design, inexpensive internal memory can be in excess of 1 million bytes (1 megabyte). Similarly, relatively low cost mass storage devices are now readily available which can store in excess of 40 million bytes of data.

The increased availability and reduced cost of RAM memory and mass storage, has to a certain extent, eased the previously imposed memory restraints. In the early 1980's some computer languages were directly transferred from 8-bit to 16-bit machines without modifying them to allow for the availability of increased memory. This in effect produced a barrier which limited programme length to within 64k. Memory segmentation (Morse, 1982) allowed programmes to exceed this limit, but it seriously reduced programme portability. Improved versions of computer languages have now alleviated this problem, although in certain instances once the 64k barrier is passed programme speed can be reduced dramatically.

The Zorland "C" package contains 4 memory model compilers which give flexibility in programme design. The small model allows for programmes within the 64k barrier and is the most efficient. The other 3 models allow handling of programmes or data in excess of 64k, but with a reduction in efficiency and speed (Zorland, 1986b).

The method in which data are stored in memory and on disc is controlled by the programmer. Limited amounts of data can be contained in the programme, or loaded into memory in the form of sequential files (Knuth, 1971-83), but this tends to use large amounts of memory capacity which in effect controls the size of programme and in many instances reduces speed of operation.

When large data-files are produced, e.g. those storing data for the University of Bath assessment model, it is essential that disc drives are utilised and that the data is stored efficiently in Random Access files. Poorly structured data-files can consume large amounts of disc storage space and severely reduce programme efficiency.

In an attempt to maximise programme operation the assessment model data have been stored using specialised "Hashing" techniques (Schildt, 1988), and Low-Level File Input/Output (Purdum, 1985a). Hashing allows for extremely fast data retrieval, but for the most efficient use of the Hashing technique, the data-files must be approximately 30% larger than conventional types. This leads to a reduction in the efficiency of storage, but an increase in operation speed.

8.2 PROGRAMME EXECUTION SPEED

The execution speed of a programme is affected by the speed at which individual microprocessors and peripherals work, and the efficiency of programme design.

The speed at which micro-computers work varies with computer design and the individual processors that are used. For example, the Victor V286C computer, based on the Intel 80286 microprocessor, runs at a speed of 10 MHz, whereas the Tandon PCA-s1 using the same microprocessor runs at 12MHz. Similarly, the physical performance of data storage, i.e. the speed at which disc drives and other storage devices work, can vary greatly. For example, the Seagate ST125R 20 megabyte hard disc has a retrieval speed of 40ms, whereas the Kyocera KY20B 20 megabyte hard disc has a retrieval speed of 64ms.

The efficiency of microprocessors and peripherals in relation to execution speed, is controlled by design. This means that in normal circumstances their performance, and subsequent execution speed of programmes, cannot be improved by the software engineer (programmer). Conversely, it is very easy for poor software design to lead to inefficient programmes, even when they are running on the most modern machines. For example, the execution speed of the following short BASIC programme can be increased by up to 30 times (Microsoft, 1979) simply by using integer as opposed to single precision variables.

```
10   FOR I=1 TO 10
20   A(I) = 0
30   NEXT I
```

"C" is a compiled language, whereas BASIC is what is known as an Interpreted language. BASIC programmes are stored in memory as a list of numbered lines (see above), but each line is not available as an absolute memory address during interpretation. The BASIC interpreter translates a programme into the computer's machine language (code) a line at a time as the programme is run. This means that before a programme can be executed it must be translated into machine language and checked for errors. Each translation takes up some time and when a long BASIC programme is executed the speed of operation can be seriously affected. Unlike BASIC, "C" programmes must be compiled before they can be executed, which in effect means that programme statements are available as absolute memory addresses and no further interpretation is necessary during execution. Programmes compiled in this way can dramatically increase operational speed. For example, the execution speed of the following short programme can be up to 50 times faster than an equivalent Interpreted BASIC program (Purdum, 1985b).

A PROGRAMME TO COUNT FROM 1 TO 30000

```
/* Increment variable to 30000 */
£include <stdio.h>
£define BELL 7
£define GOAL 30000
main()
{
int x;
putchar(BELL);
x=0;
while (x != GOAL)
++x;
putchar(BELL);
printf("Loop finished\n at the bell.\n");
}
/* end of program */
```

Global optimising "C" compilers are also available, which give a further increase in programme execution speed and a reduction in programme size. They achieve this by carrying out expression reordering and sub-expression elimination (Zorland, 1986b). As a generalisation, execution of a compiled programme can be 3-10 times faster than the same programme running in BASIC, and with the maximum use of integer variables speed increases of up to 50 times can be obtained.

The University of Bath micro-computer assessment model was written in Zortech "C" with the maximum use of integer variables, and it was compiled into machine code language using the Zortech "C" Global Optimising compiler. All graphical output was based on the Zorland Graphics Toolkit which optimises its output by printing directly into video display memory. Other techniques, such as Hashing and Low-Level file input/output, were also included to obtain maximum execution speed. Each program was developed within the limits of the Zortech "Small" model, i.e. less than 64k of code, which meant that the most efficient compiler was used.

8.3 THE TIME TAKEN TO COMPLETE THE PROGRAMMING

The time taken to develop a programme will depend upon the complexity of the problem, the computer language used, the skill of the programmer, the availability of specialist programming knowledge, and the required overall User Friendliness of the completed work.

Given enough time every aspect of a programme could be maximised by producing a series of alternative solutions to individual problems and then carrying out detailed benchmark tests to assess the efficiency of each. In practice this type of maximisation is usually too time consuming and a trade-off between time and efficiency becomes necessary.

The selected language will affect the time taken to develop a programme. Interpreted languages, e.g. BASIC, allow the programmer to produce code and test it immediately without first compiling it. Having said that many modern BASIC packages, e.g. Microsoft Quickbasic 4.0 (Microsoft, 1987b) contain compilers which produce fast efficient programme code without the necessity of leaving the programming environment. Another major advantage of interpreted languages is that if an error (Bug) occurs in the programme, the interpreter will usually stop programme execution and list the actual line where the error was found. It will then continue by describing the type of error, e.g. syntax, or jumping to an undefined line number.

Programmes written in "C" have to be compiled before they can be executed, which means that programme development and testing can become extremely slow and tedious. Unlike most BASIC interpreters, "C" allows almost total flexibility in programme design, however, most compilers will only "Flag" a relatively few errors. This means that if an unidentified error occurs, the programmer may not get any help in isolating it; this type of error can take an extremely long time to find and correct.

One of the major problems of developing programmes on a micro-computer is the acquisition of suitable programming knowledge. In the past most programmes were developed on large mainframe computers, and in a wide variety of languages. Although the techniques of mainframe programming are often available, e.g. via university computer departments and scientific publications, their modification and implementation onto micro-computers is often extremely complex and time consuming. The problem is compounded by the fact that most contemporary micro-computer literature is produced for the novice/hobbyist markets, with few suitable technical works being published.

Many micro-computer programming procedures, which would be extremely useful in the development of an assessment model, have been developed "In-House" by commercial companies, but these organisations are, understandably, often very reluctant to release their knowledge into the public domain.

The majority of the specialised programming procedures in the University of Bath micro-computer based assessment model, e.g. the search algorithms and hashing techniques, have by necessity, been developed by the author, although a number of specialist publications, e.g. Fundamental Algorithms (Knuth, 1971-83), Programming and Algorithms (Guttmann, 1977) and "C" the Complete Reference (Schildt, 1987), were also consulted. Where no detailed information was available the development and assessment of new procedures was extremely complex and protracted.

8.4 THE USEFULNESS OF THE FINISHED PROGRAMMES

Once individual programmes have been developed and programmed they must be assessed to check if they perform their required tasks in an efficient, practical and User Friendly manner. They must also be assessed on their relative ease of use by computer illiterate people, i.e. people with little or no experience of micro-computers. Having made an initial assessment the programmes are then modified to comply with the required standards.

One of the most difficult problems a programmer has to solve is the inclusion of new features suggested by the people who carry out the alpha and beta tests, i.e. the initial assessors. The structure of the "C" programming language makes this problem relatively easy, although in certain instances, major re-writes have to be carried out.

The University of Bath micro-computer based assessment model was made available to a number of decorative horticulturalists, local government officers, university and college lecturers, and ADAS advisors. Each individual assessed the overall complexity of the package, but in particular the ease in which the programmes could be used, and the accuracy of the "Tender" species and intolerance data. Each person isolated a number of errors and suggested programme improvements.

8.5 RELIABILITY OF THE HARDWARE AND PROGRAMMES

The reliability of micro-computers and the programmes they run is affected by the quality of electrical supply, the vulnerability to equipment malfunctions and operator errors, and the number of programming errors, or "bugs".

A. Electrical supply.

The quality and reliability of electrical supply varies through-out the country. In cities it is usually relatively constant, whereas in more rural locations larger fluctuations can often occur. Similarly, rural locations are more prone than urban areas to power cuts in inclement weather, although both types of location can experience sudden fluctuations in supply, commonly described as spikes, or surges.

Micro-computer data storage systems are very prone to damage, i.e. loss of data or corrupted files, during sudden fluctuations in supply. In locations where these occur regularly it is advisable to purchase electrical equipment to balance out the power supply.

Even though special equipment may be available to lessen the incidence of power fluctuations, loss of data can still occur by someone inadvertently switching off the computer, or by accidentally physically damaging the programme and data-discettes. It is important, therefore, when developing a micro-computer based model, to ensure that the programmes are designed to minimise loss of data due to unexpected power fluctuations and accidents.

The University of Bath assessment model contains climatic, site and plant related data-files which may be prone to damage during severe unexpected fluctuations in power supply. However, unlike many other systems, the data the files contain are relatively static in that they will be rarely modified and infrequently added to. This means that as long as back-up copies of the data discettes are made after each modification session the loss of data due to power fluctuations, or accidents, will be kept to a minimum, i.e. rarely more than the individual record currently being modified.

B. Equipment malfunctions.

Micro-computers are extremely reliable and require the minimum of maintenance, although in the past certain designs, e.g. Tandy TRS-80, Apple II and Amstrad PC's, have all been prone to overheating, or other design problems, which have lead to various types of malfunction.

The major problem relating to the reliability of contemporary micro-computers appears to be the hurried introduction of machines with basic design faults, and unfinished documentation. Many manufacturers and third party companies, recognise that occasional faults in computer hardware and peripherals do arise, and to alleviate these problems the companies offer comprehensive annual maintenance contracts, and 24 hour repair services. In general, once a computer has been running for approximately 3 months it is highly unlikely that any hardware malfunction will occur. This is the major reason why a number of computer companies only provide relatively short warranty periods.

The Victor V286C on which the University of Bath micro-computer assessment model was designed, required a new EGA colour monitor within the first week of operation. Victor Technologies were informed and a replacement monitor was installed within 24 hours; no other maintenance has been necessary.

C. Operator errors.

During the design phase of a micro-computer programme it is essential that adequate procedures are incorporated to enable the correction of operator errors. Each stage of interactive input must be planned to allow the operator to use the programme with the maximum efficiency and with the minimum of mistakes. No system can remove the possibility of all operator errors, but well planned programmes are designed to keep them to a minimum whilst allowing the user to correct the occasional one in a simple, efficient manner. Whatever happens the operator must never be capable of damaging the programmes by accidental input.

The University of Bath micro-computer assessment model has been designed to reduce the incidence of operator errors. All interactive input is rigidly controlled and monitored, and typographical errors are highlighted via display prompts. All the programmes are "MENU" driven and a series of ESCAPE sequences have been incorporated which enable the user to quickly and easily abort the session, or cancel selected options.

The Victor and IBM ranges of micro-computer have a number of FUNCTION keys at the top of the keyboard. These can be modified to become equal to whatever the programmer wishes, e.g. the "F1" key could, if required, be re-defined to allow the user to escape to the Main programme Menu. This facility enables the programmer to reduce operator errors by cancelling the use of unnecessary, or potentially dangerous keys, and reinstating them as and when required. The current assessment model is a "first attempt" at producing a working system. To maintain portability of the programmes, and to keep the source code as simple as possible, none of the function keys have been modified.

D. Programming errors.

A major part of programme development is the removal of programming errors, commonly called "Bugs". Many types of error can exist, ranging from faulty syntax to incorrect programme logic. Before any programme is suitable for general use it must be tested, preferably by both experienced and inexperienced users, and finally it must be thoroughly de-bugged. Unfortunately, the de-bugging process can be very complex and time consuming, and there can be no guarantee that all errors will be removed. In fact, unexpected errors often appear after programmes have been in use for a considerable length of time, e.g. the "Quill" wordprocessor (Psion Ltd, 1984) still contained numerous programming errors after at least one re-write and two years on general release.

The University of Bath assessment model has been thoroughly tested by both the author and a number of inexperienced and experienced users. After the programmes had been written they were compiled using the Zortech Global optimising compiler. During the process of compilation all syntax was automatically checked, and existing problems were highlighted before compilation was complete. This gave the opportunity of correcting the errors before the final "Object" code was produced.

8.6 THE EASE OF MAINTAINING THE PROGRAMMES

By conforming to recognised standards it is possible to design a system which is highly maintainable and understandable by other programmers, i.e. easy to find and correct programme errors, but in order to achieve this, the programmer may often have to sacrifice the use of procedures that are best suited to an individual application.

Easily maintained and understandable source code, i.e. the original programme, must be well structured, and all variables and strings (collection of characters) should have clear logical names. Zortech "C" allows the programmer to use up to 31 characters when defining variables, which means that self explanatory variable names can be used. Wherever possible copious notes relating to every aspect of design and individual procedures should be produced and the source code should contain frequent remark (/* Rem */) statements.

Where BASIC programmes are internally well documented the length of the source code will be extended. However, once a programme is complete, and preferably free from all known errors, it is possible to keep a copy containing the remarks, but run it with them removed. This reduces the size of the programme, whilst maintaining a documented form. "C" programmes, on the other hand, may be documented as much as the programmer wishes. During the compilation process all remarks are ignored and compact code is automatically produced.

The University of Bath micro-computer assessment model contains two programmes each of which requires in excess of 62,000 bytes of memory. Both were developed in a modular form using Zortech "C", and each module was internally documented and thoroughly tested before being "merged" into the final source code. If all internal documentation, self explanatory variable names and easily understood programme logic had been retained, each programme would have been in excess of 64,000 bytes of memory, i.e. greater than the Zortech "C" small compiler model can handle. To reduce programme size to less than 64k some rationalisation of the source code was necessary.

8.7 OVERALL ATTRACTIVENESS OF THE PROGRAMMES

Well designed video displays which guide the operator to the important sections of the screen, can dramatically affect the use of a micro-computer programme. Simple, well laid out displays allow the easy selection of available options, whilst maximising operator speed. Conversely, highly complex, uneven displays can have totally the opposite effect.

Where a series, or package of programmes are designed it is important to ensure consistency in lay-out and design, e.g. maintain the prompt messages in the same position in each programme. It is also important to develop a simple to use method of option selection, which is reliable, whilst maintaining operator errors to a minimum (Lodge, 1989).

The number and complexity of video displays will affect the length of a programme. However, once the displays have been designed and entered into the computer they can be saved onto a discette and loaded whenever necessary. This reduces programme length, but severely reduces compatibility with other computers and slows down operation speed.

Individual micro-computer manufacturers design their systems to provide video display output. Unfortunately, with IBM compatible machines, there is no industry standard for this output, which means that there is a wide variance in the way screens are addressed, even though the micro-computers may use the same microprocessor. This variance severely restricts the movement of programmes from one machine to another.

The University of Bath micro-computer based assessment model provides video display output using a colour Enhanced Graphic Adapter (EGA), commonly known as an EGA monitor. All visual display output was designed using the Zorland Graphics Toolkit, which runs under the standard Digital Research "GEM" interface (Zorland, 1986a).

8.8 DOCUMENTATION OF THE HARDWARE AND PROGRAMMES

The introduction of relatively cheap micro-computers in the mid to late 1970's has lead to a dramatic increase in professional and hobbyist usage. When third party software first appeared on the market it tended to be of poor quality, containing frequent programming errors, and was supplied with totally inadequate documentation. Even today, one of the major criticisms of high quality professional software and micro-computers, is the lack of consistently good documentation.

Before any computer and software can be used two types of documentation must be available. Firstly, the operator should read the manuals concerning the actual computer, and become familiar with the keyboard, disc drives and general maintenance requirements of the machine. This can be a rather traumatic experience for inexperienced personnel, especially as in many cases the manufacturers documentation leaves much to be desired, and the operator is expected to learn the use of the machine in total isolation.

The use of individual software packages should only be contemplated after the machine familiarisation phase has been completed. It is at this time, i.e. when the programme and data discettes are first entered into the computer, and when the operator is unsure and possibly hesitant, that most serious and damaging mistakes occur.

The second type of documentation which the operator must become familiar with is the "User Manual" for the specific software product. This should lead the new operator through the first troublesome period, following on in a gradual process to the uses and intricacies of the software.

User manuals are extremely difficult, time consuming and expensive to produce. The author must take into consideration all target populations, because computer illiterates and experienced operators require totally different approaches. He must also ensure that all the features of the package are fully described. Wherever possible diagrams should be used to illustrate major screen displays and a comprehensive glossary of terms should also be provided.

The University of Bath micro-computer assessment model consists of three major software programmes and a "User Manual". The Victor V286C micro-computer has a standard enhanced English, IBM type keyboard, which means that its key layout is the same as the majority of modern micro-computers. However, a number of differences with early keyboards, e.g. 102 keys, may exist. The "User Manual" outlines the use of the programmes on the standard IBM keyboard layout, and makes no mention of other types, or layouts.

SECTION II

FEATURES OF THE UNIVERSITY OF BATH
LANDSCAPE ASSESSMENT MODEL

Meteorological Office information (Smith, 1984), whereas the majority of the soil and site related data have been collated from records supplied by the Soil Survey of England and Wales (Lawes, 1983).

The model will also allow the user to select and assess taxa for specific sites and climatic conditions. The plants are stored in two large data-files; the first providing information on potential hardiness (volume II, Appendix C), and the second, highlighting potential plant intolerances (volume II, Appendix D).

2.0 THE CLIMATIC MODEL

The climate related section of the model has been based around 70 map reference areas as illustrated in volume II, Appendix A, Fig. 1. The original zonation was derived from Meteorological data (Smith, 1984), however, the actual reference zones were modified in line with James Hitchmough's (1984a) and Frank Hopes (1986a) previous work. During execution of the model these zones assume the role of "key identifiers".

When the assessment model is first entered the user must identify the location of his site, i.e. which of the 70 climatic zones the site is in. This can be accomplished in two ways. The first is by initially locating the site's grid reference on the relevant 1:50,000 Ordnance Survey Landranger map, and then, using the appropriate location map, (volume II, Appendix A, Figs. 2 to 11) plot its position and altitude. The zone in which it is located is the reference area for the climate related enquiries.

The second method of identifying a site is by simply typing into the model the name of the town/city in which the site is located. The model has been pre-programmed with reference area information for all English and Welsh towns/cities listed in the 1972-73 Whitaker's Almanacs, i.e. prior to local government re-organisation (volume II, Appendix B). If the selected site is pre-recorded the model will automatically load the relevant data, if not the user will be informed and offered the opportunity to select another town; the facility is also available to enter and store new location information.

2.1 AVAILABLE CLIMATIC MODIFICATIONS

The basic data for all climatic assessments have initially been calculated for each zone and do not take into consideration micro-climatic factors and altitude, which can have a modifying effect on the site and there by the range of taxa grown.

A number of factors may adversely affect the climate of specific sites. For example, low lying areas surrounded by higher land, produce valleys which can develop appreciable temperature differentials

(Manley, 1944, George, 1963, Geiger, 1964). It has been shown that low temperature damage produced under these conditions can have a serious effect on the establishment and subsequent growth of a range of ornamental taxa (Shaw, 1978).

Not all micro-climatic factors have an adverse affect on a site. In urban areas it has been shown that air temperature readings can be between 2.0 and 5.0 degrees centigrade warmer than surrounding rural areas (Chandler & Gregory, 1976). Similarly, localised boundary layer heat islands associated with the air - solid interface of buildings can also contribute to the differentials between the built and none built environment (Hitchmough, 1984a, Tanner, 1974, Oke, 1978). The value of wall generated heat islands has been recognised for a considerable length of time, and it is frequently exploited by horticulturalists (Wright, 1976, Stephenson, 1981).

Other models, (White, 1977, Hitchmough, 1984a, Hope, 1986a) have identified and attempted to quantify some of the effects of micro-climate in relation to plant growth. The method of quantification has by necessity been highly mathematical, utilising a combination of complex formulae and zonal estimates.

The University of Bath assessment model does not contain all micro-climatic adjustment factors which affect the climate of a particular site. However, it does allow the user to modify the climate by adjusting the site's altitude, exposure and proximity to the coast.

2.1.1 ALTITUDE

A number of climate related parameters, e.g. air temperature and rainfall, are affected to some degree by altitude. As the altitude of a site increases climatic changes occur which can adversely affect the establishment and growth of ornamental taxa.

James Hitchmough (1984a) suggested that 5 altitude ranges, i.e. 0-75m, 75-150m, 150-225m, 225-300 and 300-375m, could be combined with his proposed climatic zones, to give a broad indication of the effects of altitude on growth and hardiness. The overall range of 0-375m was suggested because areas above 375m altitude are sparsely populated and unlikely to be subjected to extensive landscape planting. This work introduced a new concept of assessing successful growth of taxa within specific altitude modules or bands. Unfortunately, there is a dearth of information relating to altitude and ornamental plant growth, and some of the work is, by necessity, rather subjective.

L.P. Smith (1984) has produced a series of mathematical equations and lapse rates which can be used to give accurate estimates of the effects that altitude has on various climatic parameters. For example, he suggests that a 0.6 degree centigrade temperature adjustment should be made for every 100 metre rise or fall in height.

The University of Bath assessment model has been designed to utilise L.P. Smith's formulae and lapse rates (Smith, 1984) in all altitude related calculations. However, the "Altitude Notes" section of the model uses both Smith's work, and a modular approach. The specific altitude notes are selected when the altitude falls within the following ranges.

<u>Range of Altitude Notes.</u>

Range	Comment
0m - 120m.	Altitude not a limiting factor. No display note printed.
120m - 350m.	Altitude may become a limiting factor with certain taxa. A display note indicating the rise in altitude is printed.
350m - 670m	Altitude is a limiting factor with most landscape taxa. A display note indicates the problem.
Greater than 670m.	No ornamental taxa will survive. A display note highlights this fact.

The display of altitude related notes is dependent upon the specific altitude of a site. No comment is made until it reaches 120m, i.e. the altitude where commercial top-fruit production becomes generally uneconomic because of problems such as disease ingress (Baker, 1986). The limit of 350m has been derived from James Hitchmough's work and it indicates the height limit were the growth of the majority of hardy woody ornamental taxa will be affected in some way by altitude. J.M. Caborn (1965) and Curtis, Courtney and Trudgill (1976) have suggested that 670m is the upper limit for growth of most taxa in England and Wales, and this figure is the limit where the model indicates no establishment or growth will take place.

2.1.2 EXPOSURE

In exposed situations plant establishment and growth may be adversely affected. The most obvious symptom of this is usually physical damage, e.g. tearing of leaf tissues or breaking branches, caused by the buffeting action of strong, gusty winds. However, a more subtle, but equally important cause of damage in these situations, is the potential for the increase of transpiration. In laboratory experiments Wadsworth (1964) has shown that the general effect of increased wind speed, above a threshold of 2 to 3 ms^{-1} is to reduce the overall size of plants, although when combined with other climatic factors, such as frost (Geiger, 1959), the same conditions can have a more serious debilitating effect on both growth and survival.

Introducing the concept of an exposure rating into any taxon based model is an extremely complex operation. The main reason for this is that no definitive definition of 'exposure' is available. Attempts at mapping wind direction and strength (Oliver, 1960, Thomas, 1958, Birse & Robertson, 1970) in relation to plant size and shape have provided some data, although for various reasons most of them are unsuitable for inclusion in an assessment model.

The Soil Survey of England and Wales (Bendelow & Hartnup, 1980) have attempted to produce an exposure rating using a combination of wind speed, gustiness, direction, temperature and chemistry of the wind. Their work has resulted in the production of a Bioclimatic classification map covering the whole of England and Wales (Lawes, 1978). Categories included in their classification are as follows :

<u>Exposure Categories</u>

Description	Approximate average annual wind speed (m/s)	Vegetation effect
Unexposed	less than 4.8	Tree growth moderate to good.
Exposed	4.8 - 6.6	Tree growth poor.
Very exposed	more than 6.6	Heather very short, trees absent.

The above categories provide a useful method of classifying exposure in the general landscape, but they do not provide accurate data for more urban areas, where physical barriers and wall generated heat islands, may have a dominant effect upon the micro-climate and subsequently the range of taxa grown.

The exposure rating for the University of Bath assessment model has been based upon the Soil Survey of England and Wales classification, however, during the development of the model it was found that a further category was required to take into account the affects of very sheltered locations, such as found on sheltered south facing walls.

The initial climate modifications (volume I, Appendix A) of all 70 zones have been set using the Soil Survey's data, and the climate modification lapse rates listed below have been derived from James Hitchmough's work (1984a).

The four categories of exposure used in the assessment model are as follows :

Display Characteristic	Climate modification
Very Sheltered	+ 80 day degrees
Sheltered (unexposed)	+ 60 day degrees
Exposed	+ 40 day degrees
Very Exposed.	+/- 0 day degrees

2.1.3 COASTAL PROXIMITY

Britain is a relatively small island whose climate is affected to a greater or lesser degree by the sea. K. Smith in "Climate of Coasts and Inland Water Bodies" in 1976, recognised that sea breezes affect the climate, and he estimated that their modifying influence could extend inland for up to 65 km. However, he also recognised the fact that major modifications are usually only found within a narrow coastal band, the width of which varies depending upon local topography.

Oceanicity, i.e. the proximity to and influence of large areas of open sea (Birse, 1971), can be expressed in terms of annual and daily fluctuations of temperature, and length of the growing season. Troll (1965) who carried out research on this concept described Britain as being totally 'oceanic'; exhibiting annual temperature fluctuations less than 16°C, mild winters and moderately warm summers. He also noted that the west coast climate of Britain was affected by the gulf stream, and that in certain locations exotic taxa could be grown without the risk of damage from frost.

The Soil Survey of England and Wales (Bendelow & Hartnup, 1980) have produced a bioclimatic classification map using the concept of 'oceanicity', however, the system gives only a broad indication of the climate modification in relation to coastal and inland locations, and it is therefore unsuitable for direct use in a taxon-based model.

The University of Bath assessment model has utilised the Soil Survey's 'oceanicity' classification map to provide an indication of coastal climate modification. As this information is very generalised, James Hitchmough's work (1984a), i.e. assessing beneficial modifications within only 3 km of the coast, has also been adopted. What this means in practice is that the model will allow a single mean annual modification of 40°C for any site within a 3 km band of the coast. The overall mean will, however, be subject to further modifications due to the degree of exposure and altitude.

2.2 MAJOR CLIMATE RELATED CRITERIA

The University of Bath assessment model contains data relating to 16 major climatic criteria. The original data were in the form of 12 monthly, areal averages for each of the 70 climatic zones (Smith, 1984), but in the model, where suitable data were available, they have been sub-divided to cover both the growing and dormant seasons (volume I, Appendices B & C). Micro-climate adjustment factors have also been included which allow modifications relating to altitude, coastal proximity and exposure. The climatic criteria are as follows :

1. Air temperatures;
2. Earth temperatures;
3. Rainfall;
4. Potential transpiration;
5. Effective transpiration;
6. Total hours of sunlight;
7. Daylength;
8. Solar radiation;
9. Illumination;
10. Accumulated day degrees above 10°C;
11. Accumulated winter day degrees below 0°C;
12. Last expected spring frost;
13. Soil moisture deficit;
14. End of soil moisture capacity;
15. Return to soil moisture capacity;
16. Excess winter rain.

2.2.1 AIR TEMPERATURES

The assessment model contains data relating to mean air temperature readings for each of the 70 climatic zones. The data have been derived from Meteorological Office records (Smith, 1984) for the 30 years between 1941 - 1970, and are accurate in most locations to within plus or minus 0.1°C, although in upland areas this can drop to plus or minus 0.2°C. The data are further sub-divided to highlight mean air temperatures during the growing and dormant seasons and an altitude correction factor, i.e. lapse rate, for inland locations, of

0.6°C per 100m rise or fall has been derived from Smith's data.

2.2.2 EARTH TEMPERATURES

The assessment model displays data relating to mean earth temperatures (30cm depth) for each of the 70 climatic zones. The data were derived from Meteorological Office records (Smith, 1984), but as with air temperatures (see 2.2.1 above) they were sub-divided into growing and dormant seasons. The approximated accuracy of the data is plus or minus 0.2°C, although greater variation will exist in upland areas.

Smith analysed the data from two sets of stations, one in the northern Pennines over a 77-566m range, and the other in north Wales over a 5-386m range. His results showed that the mean annual variation with height is very similar to the equivalent for air temperatures, i.e. mean earth temperature variation = 0.66°C per 100m rise or fall. This figure has been used to provide an altitude correction factor for use within the model.

2.2.3 RAINFALL

Rainfall in England and Wales is fairly evenly divided throughout the year, especially in the drier, low-lying areas. For example, the 10 year average annual rainfall for the Thorney area of

Cambridgeshire (NLIDB, 1987) is 558.75mm with approximately 283mm of that falling during the winter months.

The amount of rainfall a site receives varies considerably with height; the only higher level sites receiving relatively low rainfall are those which are sheltered and lying in 'rain shadows'. Smith (1984) found that, with the exception of rain shadowed sites, the increase of annual rainfall with height had a high correlation with the average rainfall for the zone in question. He suggested that an approximation to the rate of increase in any of the agro-climatic areas could be calculated as follows :

$$0.315R_m - 119\text{mm}/100\text{m}$$

(R_m = areal average annual rainfall in millimetres.)

The University of Bath assessment model uses Meteorological Office derived averages for the 30 year period between 1941-71 (Smith, 1984) to indicate the mean rainfall for each of the 70 climatic zones. A modification relating to the height of any individual site is estimated using the above equation.

2.2.4 POTENTIAL TRANSPIRATION

Potential transpiration may be considered as the amount of water that could be transpired by a green crop of the same colour as grass, which completely covers the ground and which has an adequate available supply of soil water at its roots (MAFF, 1954).

Evaporation of water from a plant surface and transpiration from stomata are similar in nature, and are governed by similar factors. If values for solar radiation, wind speed, temperature and humidity are known, then a 'potential transpiration' rate may be calculated (Penman, 1963, Messem, 1975).

The highest values for potential transpiration are usually found in coastal areas where the sunshine and radiation are stronger than in more inland localities, although large fluctuations can occur with respect to a specific site's altitude.

As altitude increases potential transpiration decreases. The following data, collected from stations at Carlisle, Eskdalemuir and Great Dun Fell (over a range of 850m) give an indication of potential transpiration, in millimetres per 100 metres, for both summer and winter.

Monthly Figures Suggested for the Decrease of Potential Transpiration with Height in England and Wales. (Data derived from Met. Office, 1984)

MONTH	mm/100m	MONTH	mm/100m
April	3.5	January	1.5
May	3.5	February	2.0
June	3.0	March	3.0

July	3.0	October	1.5
August	2.5	November	1.0
September	2.0	December	1.0
SUMMER	17.5	WINTER	10.0

The assessment model utilises Meteorological Office data (Smith, 1984) to predict the potential transpiration for any location in England and Wales; the calculations are thought to be accurate to within plus or minus 2mm. A correction factor of 17.5mm reduction per 100m rise in height during summer and 10mm reduction per 100m rise in height during winter have been used to provide a correction factor for variations of potential transpiration due to altitude.

2.2.5 EFFECTIVE TRANSPIRATION

Potential transpiration (see 2.2.4) is estimated as, the amount of water that could be transpired by a green crop of the same colour of grass, which completely covers the ground, i.e. has a leaf area index of 1, and which has an adequate available supply of soil water at its roots. Unfortunately, in practice, crops do not always cover the ground, for example there is bare soil between annual row crops for 80% of their field life (Winter, 1978). In addition to this, potential transpiration figures do not take into account the presence of summer soil moisture deficits.

The calculation of effective transpiration takes into account the effects of soil moisture deficits by only summing potential transpiration figures when less than 50mm of soil moisture deficit occurs in the main root zone of the soil. This means that it is a measure of solar energy input over the period when no limitations due to soil moisture deficits or soil temperature occur.

The University of Bath assessment model uses data derived from the Meteorological Office (Smith, 1984) to provide a prediction of effective transpiration at any site in England and Wales. As effective transpiration does not vary uniformly with height, and it cannot be deduced directly by average figures of growing season, potential transpiration and rainfall, no micro-climatic correction factors have been included.

2.2.6 TOTAL HOURS OF BRIGHT SUNLIGHT

The assessment model displays the mean daily hours of bright sunshine, as measured by a Campbell-Stokes recorder, for each of the 70 climatic zones. The data have been derived from the Meteorological Office's records for the years 1941-1971 inclusive, and are estimated to be accurate within plus or minus 0.1 hours per day in winter and approximately 0.2 hours per day in summer.

The amount of direct sunlight falling on a site is affected to some extent by industrial atmospheres, topography and shade from buildings and trees. However, it is also affected by height above sea level, and coastal proximity.

The assessment model contains a modification factor relating to coastal proximity. The correction was derived from the following figures relating to 25 representative stations :

Decrease of Sunlight for Every 10km Increase in Distance from the Nearest Coast

(Data derived from Met. Office 1984)

Season		Hours per Day
Spring	-	0.05
Summer	-	0.04
Autumn	-	0.03
Winter	-	0.02

A variation in height deduced from the same investigation showed a loss of 0.11 hours per day in winter and 0.18 hours per day in early summer, for every 100m increase in height. These figures were used for the assessment model's altitude correction factor.

2.2.7 DAYLENGTH

Each of the assessment model climatic zones contains a figure for estimating daylength. The data has been Abstracted from Reed's Nautical almanac (Reed, 1989), and relates to the mid-latitude points for each of the zones. The figures are expressed in units of hours and tenths of hours, i.e. not hours and minutes. No correction factors are available.

2.2.8 SOLAR RADIATION

The range of solar radiation experienced over England and Wales is relatively small, with average values for the period April-September varying from 200 to 270 w/m^2. However, the range of extremes is much greater, and for the same period, it may fluctuate during daylight hours from 50-900 w/m^2 (Cibs, 1979).

The base solar radiation data for the University of Bath assessment model have been extracted from the HMSO booklet number 435 (Smith, 1984) and are initially displayed as the power unit, milliwatt hours per cm^2. As this is a rather inconvenient parameter (Hitchmough, 1984a), a further display using mean watts per m^2, has also been included. This does introduce a small amount of error due to daylength inaccuracies, but for most situations it is negligible and has been ignored. The conversion was obtained by using the following equation :

$$w/m^2 = \frac{\text{milliwatt hours per cm}^2}{\text{day length}} \times 100$$

The solar radiation which a plant intercepts is only a percentage of the maximum available; it can be increased or decreased by site selection (Landsberg, 1972-73). Solar radiation levels are highest in the immediate vicinity of the coast, and there is a marked decrease in level as altitude increases. The amount of variation with altitude between the north and south of England and Wales can be highlighted as follows :

<u>Decrease of Solar Radiation with Height</u>

(Data derived from Met Office, 1984)

Milliwatt hours per cm^2 change per 100m height.

MONTH	NORTHERN ENGLAND	SOUTHERN ENGLAND
January	2.1	1.7
February	3.9	3.0
March	6.4	5.2
April	8.3	7.0
May	8.4	7.7
June	8.2	7.4
July	8.0	6.9
August	7.4	6.6
September	5.8	5.5
October	3.8	3.5
November	2.1	2.0
December	1.5	1.4
Total	65.9	57.9

The mean totals and their w/m^2 equivalents were incorporated into the assessment model as correction factors for altitude calculations. No data relating to coastal proximity were available, and therefore, no modification for this parameter was included.

2.2.9 ILLUMINATION

The Meteorological Office (Smith 1984) record illumination data in kilolux-hours at a number of stations throughout England and Wales. Because these units are really based upon the sensitivity of the human eye, rather than on that of plant pigments such as, chlorophyll, phytochrome, or a blue-light receptor, they are of limited value in the investigation of the effects of radiant energy on plants. The Meteorological Office illumination data have been included in the model for completeness, and to maintain consistency with previous climate related work (Hitchmough, 1984a, Hope, 1986a).

2.2.10 ACCUMULATED DAY-DEGREES ABOVE 10°C

Britain, when compared with larger continental land masses at equivalent latitudes, has relatively low growing season temperatures. Sutcliffe (1977) suggests that this, coupled with increasing altitude and exposure, effectively limits the tree line in Britain to approximately 600 metres above sea level. He also suggests that it is growing season air and soil temperature, (plus the restraints of solar radiation levels), as opposed to winter temperatures, which effectively defines this limit.

Each taxon has an optimal temperature for growth, but unfortunately the establishment of that temperature is often complicated by the fact that taxa do not develop under constant temperature conditions, and the inter-relationship of other factors, such as, altitude, exposure and ecotype all have a significant effect on growth and establishment.

Accumulated temperatures above a known base figure have been used by a number of researchers to estimate plant growth stages, or the warmth of the growing season. Birse and Dry (1970) in Scotland have used temperatures above a base of 5.6°C, to give an indication of the warmth of the environment during the growing season. Both Hitchmough (1984a) and Hope (1986a) have used 10°C in relation to growth of hardy ornamental taxa, whilst Daly (1982/3) has used 0°C as a base for a fertiliser predictive sequence. Jones (1985) has also used 0°C for the development of a site related temperature map.

The University of Bath assessment model contains data relating to accumulated day-degrees above 10°C for the period of May to October. The data have been derived from Meteorological Office records (Smith,

1984) and are available for each of the 70 climatic zones.

The main factor affecting accumulated temperature is height above sea level. The changes with height for the May to October 10°C total are as follows :

<u>Decrease in Day-Degrees above 10°C with Height</u>

(Data derived from Met. Office 1984)

LOCATION	DAY-DEGREES PER 100m
Northern England & Wales	75 - 85
Midlands, east and south-east England	100 - 110
South-west England	110 - 115
England and Wales as a whole	90 day-degrees per 100m

The assessment model utilises the generalised figure of 90 day-degrees per 100m rise or fall in altitude as a micro-climatic modification.

2.2.11 ACCUMULATED WINTER DAY-DEGREES BELOW 0°C

The recording of accumulated day-degrees below freezing point during the winter months, i.e. November to March, is a useful method of indicating the potential winter hardiness of taxa (Birse & Robertson, 1970, Hitchmough, 1984a). However, from a meteorological point of view this method is rather deficient in that it cannot distinguish between uniform moderate cold and alternating peaks and troughs of extreme cold. Other methods, e.g. January absolute minima and January mean minima (Met. Office, 1974) may produce a more accurate effect, although their use is limited due to lack of accurate data.

Accumulated day degrees are also of limited value in assessing land capability on a national scale because frost varies regionally and occurs mainly outside the growing season. It is very important locally, however, and must be considered whenever specific site assessments are being made.

The University of Bath assessment model utilises Meteorological Office day-degree data (Smith, 1984) to provide a generalised guide to the amount of frost a site receives during the winter months.

Micro-climatic adjustment for coastal proximity has been included using a figure of -40°C for sites within 3km of the sea. This figure was derived from Hitchmough's work (1984a) and is equivalent to one of his winter cold zones.

The only other major micro-climatic variation included in the model, except for exposure (see 2.1.2), is height. The following equations derived from Smith's work have been used to provide a height related modification :

+ (5 + 0.18D) degree days (per 100m increase in height)

− (5 + 0.18D) degree days (per 100m decrease in height)

The letter D is the value of accumulated temperature (winter degree-days below 0°C) at average area height (volume I, Appendix A).

2.2.12 LAST EXPECTED SPRING FROST

An accurate estimate of when the last spring frost for any particular site will occur is almost impossible to achieve. The reason for this is that localised factors such as exposure, wind channels, type and height of vegetation, soil type, altitude, and coastal proximity can all to a greater or lesser degree, affect the amount of frost a site receives.

The assessment model contains data derived from Meteorological Office records (Smith, 1984) which provide a broad estimate of when the last spring frost will occur in each of the 70 climatic zones.

2.2.13 SOIL MOISTURE DEFICIT

During the summer months in England and Wales, evapo-transpiration usually exceeds precipitation, which means that some degree of soil moisture stress is likely to occur on the majority of sites. However, other than in the first two years after planting, the stress is usually insufficient, except in areas which experience above average soil moisture deficits, to cause a depression in vegetative growth, or a morphological change in plant structure, e.g. a reduction in the size of new leaves.

The term soil moisture deficit describes the amount of water by which the current soil moisture status falls short of field capacity (Winter, 1978), i.e. it is a measure of depletion of the available water reserves. It is usually expressed in precipitation terms and hence the deficit equals the maximum amount of precipitation, or irrigation, which the soil can currently absorb without drainage occurring.

The direct measurement of water deficits in the general landscape environment is impractical because of the large number of measurements required to allow for soil variation, however, deficits can be estimated satisfactorily from published meteorological records of potential transpiration and rainfall (MAFF, 1982).

The assessment model incorporates data relating to each of the 70 climatic zones. The data were derived from Meteorological Office records (Smith, 1984) and Soil Survey of England and Wales moisture deficit maps (Bendelow & Hartnup, 1980, Jones, 1985).

The main factor affecting variation with locality is a rise in altitude, which in effect, normally results in higher rates of precipitation. The approximate decrease with height of soil moisture deficits may be estimated using the following lapse rates :

<u>Approximate Decrease of SMD with Height</u>

(Data derived from Met. Office, 1984)

LOCATION	REDUCTION OF SMD PER 100m
Northern England & Wales	20 - 25mm
Midland England & Wales	20 - 25mm
South-eastern England	25 - 30mm
South-western England	30 - 35mm

The assessment model utilises the above lapse rates to provide a micro-climatic modification for each of the 70 climatic zones.

2.2.14 SEASONAL END OF FIELD CAPACITY

Field capacity may be defined in meteorological terms as a condition of zero soil moisture deficit (Robson & Thomasson, 1977). This implies that any deficit built up during the previous growing season has been made good by sufficient rainfall or other means.

In most locations in England and Wales soils are at, or are very close to field capacity until the end of march. The reason for this is that until this time precipitation usually exceeds transpiration. By April, however, the amount of rainfall decreases and an approximate balance between rainfall and transpiration occurs. By May the rate of transpiration has increased and there is usually a decrease in rainfall; this leads to a loss of soil moisture reserves, resulting in the development of a moisture deficit.

A knowledge of when a soil is at or below field capacity can aid in the development of a planting programme. If work starts too early, i.e. when the air spaces of the soil are full of water, soil structure may be damaged, with a subsequent drop in survival rate. Similarly, waiting until the soil has built up a significant deficit can lead to losses due to lack of available moisture.

The assessment model contains data derived from Meteorological Office records (Smith, 1984) relating to the prediction of end of soil moisture capacity. The data are available for each of the 70 climatic zones, and a modification for height above sea level has been based on the following lapse rates :

Onset of Soil Moisture Deficit due to Altitude

(Data derived from the Met. Office. 1984)

LOCATION	DAYS PER 10m RISE OR FALL
North-west England & Wales	1.0 day

North-east England	1.5 days
Midlands	1.5 days
East of England	1.5 days
South-east England	1.5 days
South-west England	2.5 days

2.2.15 RETURN OF SOIL TO FIELD CAPACITY

The time of year when a soil is returned to field capacity by rainfall should effectively regulate the timing of site operations, e.g. lifting from a nursery and planting stock on specific sites. It also has a controlling influence on the range of taxa grown. Sites which return to capacity early in the season are liable to structural problems and can be prone to water-logging. Soil preparation and planting time can be severely limited, and maintenance schedules can be extremely difficult to organise.

The assessment model displays, for each of the 70 climatic zones, a prediction of when a soil will be returned to field capacity. The data have been derived from Meteorological Office records (Smith, 1984) and a micro-climatic modification factor for height has been obtained by using the following lapse rates :

The Adjustment, due to Altitude, of the Date when a soil is Returned to Field Capacity in Autumn.

(Data derived from the Met. Office, 1984)

LOCATION	DAYS PER 100m RISE OR FALL
Northern England	25 - 35 days
Wales & Midlands	35 - 40 days
Eastern & South-eastern England	35 - 40 days
South-western England	40 - 45 days

As altitude increases soils are returned to field capacity earlier in the year, i.e. in Northern England it is reached between 25-35 days earlier for every 100m rise in altitude, and is reached between 25-35 days later for every 100m fall in altitude.

2.2.16 EXCESS WINTER RAIN

Any water which falls on a site after field capacity is reached is lost through evaporation, transpiration, and drainage, otherwise it is retained on the soil surface as puddles. The amount of excess winter rain is calculated by totalling all the water a site receives after field capacity is reached, minus a figure for evaporation and the amount transpired from any plants on the site. In horticultural and agricultural terms this is useful as it gives an indication of the demands made on the drainage system and the degree of leaching of lime or nutrients.

The base excess winter rain data used in the assessment model have been derived from Meteorological Office records (Smith, 1984), and no micro-climatic adjustment factors have been included.

3.0 SOIL AND SITE RELATED CRITERIA

For any establishment and growth model to be effective it must take into consideration specific aspects of both individual soils and sites. The University of Bath assessment model allows the user to specify and modify up to 15 soil and site related criteria, all of which can have a major effect on establishment and subsequent growth. The selection criteria are listed below, and a detailed breakdown of all the pre-recorded settings is printed in volume I, Appendix D.

Soil and Site related criteria

1. Soil textural group;
2. Soil depth;
3. Soil drainage characteristics;
4. Groundwater effect;
5. Slope;
6. Possibility of erosion;
7. Soil structure;
8. Presence of soil pans;
9. PH rating;
10. Organic matter content;

11. Calcium carbonate content;
12. Soil nutrient status;
13. Artificial protection;
14. Weed control;
15. Artificial irrigation.

3.1 SOIL TEXTURAL GROUP

Soil texture is the name given to the relative proportion of sand, silt, clay, and humified organic matter in a soil (Curtis, Courtney & Trudgill, 1976). It has an influence on the susceptibility of soils to erosion and the stability of structure, i.e. the risk of slaking and compaction (Shepherd, 1986), but it also influences plant suitability and to a lesser degree the risk from soil borne diseases and pests.

ADAS and the Soil Survey of England and Wales have adopted the same textural system. It consists of 6 major groups, plus an additional 3 specific organic matter groups (Advisor, 1986). An outline of the classification is as follows :

ADAS Textural Classification.

TEXTURAL GROUP	TEXTURE CLASS
Sands (less than 10% clay)	Sand (S)
	Loamy sand (LS)
Light loams (less than 18% clay)	Sandy loam (SL)

	Sandy silt loam (SZL)
Light silts (less than 18% clay)	Silt loam (ZL)
Medium loams (less than 35% clay)	Silty clay loam (ZCL)
Clays (more than 35% clay)	Clay (C) Silty clay (ZC) Sandy clay (SC)

Note : The letters in brackets indicate the recognised abbreviation.

If a soil contains between 8 and 20% organic matter it is given the prefix "organic", e.g. Organic clay loam. Soils containing greater than 20% organic matter are described as follows :

<u>Organic Based Soils</u>

TEXTURE GROUP	ORGANIC MATTER CONTENT
Peaty loam	20–35% organic matter
Loamy peat	35–50% organic matter
Peat	More than 50% organic matter.

In contemporary landscape practice many sites have their soil texture drastically modified by the total removal of topsoil or the addition of materials such as crushed brick, general building site rubble, or manufactured topsoil (Thoday & Kendle, 1990). In these circumstances the above classification is of limited use.

In an attempt to highlight the broad limitations of various contemporary landscape soils the University of Bath assessment model has been programmed to allow the user to select one of the following textural groups. The individual selections are then used to generate "Textural Notes" (volume I, Appendix E) which outline specific cultural and management related problems.

<u>University of Bath Assessment Model Textural Groups</u>

TEXTURAL GROUP	DEFINITION
Loamy	Light & medium Loams
Clayey	Clay, Silty clay & Sandy clay
Silty	Light & medium silts
Sandy	Sand, Loamy sand
Peaty	Peat, peaty loam & Loamy peat
Rubble, Spoil and Waste	Analogous to contemporary landscape sites with modified soils (see also 3.12).

3.2 SOIL DEPTH

In landscape practice the effective depth of any soil can be defined as follows :

"The depth of soil which can provide a medium for root development and anchorage, retain adequate amounts of available water and supply available nutrients."

The limiting factor affecting soil depth is usually the depth at which gravel, parent material or other unconformable rock commences. However, in contemporary landscapes, effective depth can also be affected by mismanagement of the growing medium. For example, cultivations during inclement weather can produce impermeable sub-surface layers which effectively limits the depth of the soil to the depth of cultivations.

There is no single international standard relating to depth of soil, although in most countries the differences between coding systems are slight (Hudson, 1989). The University of Bath assessment model recognises two soil depth categories, based on the Soil Survey and USDA systems (Avery, 1980, USDA, 1975). These are Shallow soils, where the depth is between 10cm and 50cm, and Deep soils, where the depth is greater than 50cm.

The model utilises the soil depth criteria to select a relevant "Soil Depth Note" (volume I, Appendix E) highlighting possible problems.

3.3 SOIL DRAINAGE CHARACTERISTICS

Soils containing a high proportion of clay have a tendency to retain a relatively large percentage of water, which is released over a long period of time. When this occurs the soil is said to be slowly permeable. In these conditions an imbalance between oxygen and water content may occur, which can adversely affect plant growth. Sandy soils on the other hand, release their water far more readily than clays, and are usually free draining or very free draining.

Most taxa prefer to grow on sites which are free draining, although a number will tolerate slowly permeable and extremely free draining soils.

The assessment model recognises two broad categories of drainage characteristics, i.e. either Well drained or Slowly permeable. For the purpose of the model well drained soils are defined as being rarely saturated in any horizon within the upper 90cm, except during, or immediately after heavy rain (Corbett & Tatler, 1970). Conversely, slowly permeable soils are defined as those consisting of more than 35% clay, but with no horizon above 60cm being saturated for more than 1 month in any year.

The model utilises the selected drainage criteria to firstly, choose and display a relevant "Drainage Note" (volume I, Appendix E) highlighting possible problems, and secondly, to draw attention to possible plant intolerances.

3.4 GROUNDWATER EFFECT

The term "Groundwater Effect" is used to describe the position of the water table in relation to the topsoil (Avery, 1980). Permanently high water tables can produce water-logged soil conditions, whereas variable tables can often lead to seasonal water-logging. On contemporary landscape sites, where conditions are often far from ideal, artificial "Perched" water tables are often produced by smearing or compacting the sub-surface layers of the soil. When a soil is water-logged all the spaces between the particles are full of water and all the soil air is driven out. If prolonged, this leads to anaerobic conditions in which few taxa can survive.

The assessment model recognises three groundwater conditions based on the Soil Survey drainage class definitions (Corbett & Tatler, 1970), these are as follows :

1. **No groundwater problem** : No water-logging takes place during any part of the year.

2. **Water-logged conditions** : Equal to the Soil Survey's "Very Poorly Drained Soil" category, where

some part of the soil is saturated at less than 30cm from the surface for at least half the year.

3. **Seasonally water-logged** : Equal to the Soils Survey's "Imperfectly Drained Soil" where some part of the soil within 60cm of the surface is saturated for several months of the year.

The model utilises the selected Ground-Water Effect criteria to firstly, choose and display a relevant "Ground-Water Effect Note" (volume I, Appendix E) highlighting possible problems, and secondly, it checks all selected taxa to ascertain possible plant intolerances.

3.5 SLOPE

The degree of slope affects the drainage characteristics of the soil, the amount of erosion which may take place and the ease of maintenance. It has also been shown that the aspect of a sloping site can affect the suitability of taxa. For example, Taylor (1958) showed that growth potential, as indicated by soil temperatures, on a north-facing slope could be estimated at 33% lower than south-facing slopes and 24% lower than west-facing slopes.

The assessment model recognises two categories of sloping land, based upon the Agricultural Land Classification (MAFF, 1966), these are as follows :

1. **Flat Land** : equivalent to the relief aspects

of grades I, II and III.

2. Steep Slopes : equivalent to grades IV and V.

The model utilises the Slope criteria to select a relevant "Slope Note" (volume I, Appendix E) highlighting possible problems.

3.6 POSSIBILITY OF EROSION

The two main causes of erosion in England and Wales are wind and water, although the location, the specific soil type and the soil management, can have a large influence on when, and if, erosion takes place. In England and Wales erosion is most likely to occur in exposed coastal areas, on steeply sloping land, or where "open" well drained sands and peats coincide with exposed conditions.

In unexposed contemporary landscapes the most important form of erosion is probably the splash, or impact effect of raindrops (Meyer, 1979). This occurs where heavy rain is allowed to fall on bare soil, and although initially not severe, it can result in relatively large amounts of erosion as well a deterioration of soil structure.

The assessment model recognises two generalised erosion categories, i.e. "No erosion problem", and "Possible erosion problem". No definition is given, but the pre-recorded soil/site records contain a rating based upon the individual Soil Survey subgroups (Lawes, 1983).

The model utilises the erosion criteria to select a relevant "Erosion Note" (volume I, Appendix E) highlighting possible problems.

3.7 SOIL STRUCTURE

Soil structure is the term used to describe the more or less temporary aggregation of soil particles. Structural characteristics, i.e. soil consistency (Hodgson, 1974) are largely responsible for a soil's handling qualities when it is brought into cultivation. For example, clays tend to be sticky when wet, and very hard when dry, whereas sands are usually friable and easily worked over a range of moisture content.

The management of stable soil structures by the maintenance of adequate organic, clay and iron colloids (Cooke & Williams, 1971), biological activity (Swaby, 1950) and cultivation policy (MAFF, 1970), is important because it controls the pore spaces between the solid particles, which in turn affects aeration and water retention. A knowledge of soil structure and how to manage it correctly can lead to increased plant establishment.

The assessment model recognises two categories of soil structure; these are "Well Structured" soils where aggregates (peds) are stable with adequate pore space and moisture, and "Poorly structured" soils where aggregates are unstable with adversely affected pore spaces and moisture.

The model does not contain a definition of soil structure; instead each pre-programmed soil sub-group contains a structure rating derived from the Soil Survey's 1:250,000 map legend. The rating is used to select a relevant "Structure Note" (volume I, Appendix E) highlighting possible problems.

3.8 PRESENCE OF SOIL PANS

Soil pans can be produced either naturally, by the downward movement of chemicals such as iron and aluminium, or artificially by the incorrect management of the soil. During podzolisation (Simon, dormer & Hartshorne, 1983) certain chemicals may be moved from the upper to lower horizons where they join together to produce a solid impervious layer commonly known as an "Iron" pan (Avery, 1980). In contemporary landscapes, soils are often worked in far from ideal conditions and artificial smearing, or compaction of sub-surface layers can occur which effectively limit the movements of soil water, and which can ultimately reduce the rooting depth of taxa (Winter, 1978).

The assessment model recognises two categories relating to soil pans, i.e. no pans present, and pans present. There is no distinction between the type of pan, its thickness, or its potential for the inhibition of establishment and growth. The category is used purely for the generation of a "warning note" which highlights the potential problems which may exist when a pan is present.

3.9 SOIL PH RATING

The pH rating of a soil is used to give an indication of how acid or alkaline a soil is. As the pH increases, or decreases chemical elements, essential for plant growth, may become more or less available (Tisdale, Nelson & Beaton, 1985). However, because of the general buffering capacity of the soil, the effect on growth of a wide range of taxa will be negligible within the pH range 8.0 - 4.0 (Jeffrey, 1987).

Most British soils have a pH which is either slightly acid, or slightly alkaline; the actual figure being controlled by factors such as the use of ammoniacal fertilisers, and crop removal or leaching of base cations (Tisdale, Nelson & Beaton, 1985). On disturbed soils, however, modified pH characteristics can be produced when topsoil is removed and subsoil is lifted to the surface.

As no precise definitive figures relating to the specific pH tolerance of the majority of contemporary ornamental taxa are available, the assessment model has been programmed to recognise three broad categories of soil pH, these are as follows :

1. **Slightly acid** : the range of approximately 6.0 - 7.0 in which the majority of hardy ornamental taxa will be unaffected by soil acidity or alkalinity.

2. **High pH** : the range greater than 7.0 where pH will generally become a limiting factor in the growth of a wide range of taxa.

3. **Low pH** : the range less than 6.0 where pH will generally become a limiting factor in the growth of a wide range of taxa.

The use of a simplified range of categories, as above, is of a limited practical value in the prediction of the growth of taxa in the real world, although it is an ideal method to use to generate a short sequence of "advisory Notes" relating to extremes of soil pH.

In addition to displaying pH related notes, the assessment model also stores taxon intolerance data. This can be used, in conjunction with the above pH categories, to highlight pre-stored taxa (volume II, Appendix D) which are intolerant of either extremes.

3.10 ORGANIC MATTER CONTENT

Organic matter has a number of contrasting effects in the soil. It releases nutrients for plant growth, increases cation exchange capacity, adds to the matrix water storage capacity, and helps in the stabilisation of soil structure.

On many contemporary landscape sites, soils can be de-natured and unsuitable for direct planting of ornamental taxa. In these situations the application of bulky organic matter can have the advantage of physically opening up the soil allowing moisture and air to penetrate.

In the past the incorporation of bulky organic matter to planting sites has been recommended as a means of improving the establishment rate, however, recent experimental work (Davies, 1987a) has shown that bulky organic matter has little, if any, effect on the rate of establishment. Similarly, other research (Patch, Binns & Fourt, 1984) has shown that some bulky organic materials can actually reduce the availability of nutrients, such as nitrogen, and they recommend that the application of large quantities of bulky organic matter should be avoided.

The assessment model recognises three categories of organic matter status; these are :

1. **Low organic matter** : i.e. less than 1.5%;

2. **Moderate organic matter** : i.e. between 3 and 6%;

3. **Bulky organic matter applied** : i.e. the addition

of the equivalent of 75 tonnes per hectare.

Each of the three categories generates an "Organic Matter Note" which highlights the possible advantages and disadvantages of high and low organic matter contents.

3.11 CALCIUM CARBONATE CONTENT

Calcium carbonate in the form of chalk is present in soils in considerable quantities over a large area of southern Britain, and when found close to the surface it can make the soil alkaline in nature. Shallow topsoils overlying calcium carbonate subsoils tend to be low in available nutrients and have a poor inherent structure.

It has been known for a long time that certain taxa, e.g. many ericaceous plants, are unable to tolerate alkaline conditions. When such plants are grown in these surroundings they become chlorotic and eventually die.

In the past landscape architects have used either personal knowledge, or plant lists (Hillier, 1981, Notcutt, 1983) to identify taxa intolerant of alkaline conditions, however, it is now becoming common place for micro-computer programmes (Hope, 1986a, Intersearch, 1989) to take over this role.

The assessment model allows the selection of either non-calcareous, or calcareous soils. The definitions of each are derived from the soil Survey's 1:250,000 map legend, and each pre-recorded location is classified using data from the legend. Each option generates a specific comment highlighting the features and possible problems relating to both types of soil.

In addition to the generation of notes the model also contains a data-file of taxa which are intolerant of alkaline conditions (volume II, Appendix D). When high alkaline soils are chosen all relevant selected taxa will generate a displayed warning.

3.12 SOIL NUTRIENT STATUS

Soils vary considerably in their natural nutrient status. Course sands usually have a low status whereas clays, loams and organic soils are usually high. Soil management and previous cropping also have a major contributing effect on nutrient levels (Binns, 1975); intensive cropping, especially monocrops, being particularly bad.

In England and Wales micro-nutrient deficiencies and excesses are not usually limiting factors for growth, although in certain conditions, such as reclaimed refuse tips, industrial wastes can produce serious excesses.

The Department of the Environment publish "trigger" levels which indicate the concentration of soil contaminants. If the levels are reached the site should be considered as a possible hazard (ICRCL, 1983), although the levels do not necessarily mean that problems will arise. Other countries, such as Holland, (Moen et al, 1986) indicate higher levels at which certain clean-up operations must take place.

Most of the contaminants listed are zootoxic, i.e. poisonous to people. They will not stop plants growing, but they do place restraints on the possible afteruse of sites, for example, they would be unsuitable for use as allotments (Kendle, 1990).

The phytotoxic elements are boron (trigger level 3 ppm), copper (50 ppm), nickel (20 ppm) and zinc (130 ppm). These represent relatively mild levels of contaminant. The tolerance to contaminants of the vast majority of taxa in the University of Bath assessment model has never been determined.

Many contemporary landscape sites contain soils which are de-natured, or have had their texture drastically modified by the incorporation of bulky inorganic materials. In addition, the structure is often in a very poor state, simply because of mismanagement. Under these conditions nutrient levels are relatively unimportant as establishment and growth will undoubtably be poor (Tisdale, Nelson & Beaton, 1985).

Most of the fine roots on bare-rooted stock will be dead by the time a tree or shrub reaches the planting site (Patch, Binns & Fourt, 1984). The thicker roots, which do not usually die, enable the plants to obtain enough moisture to survive until new fine roots can be produced. The energy necessary for this regeneration comes from stores within the plant and the nutrient status of the soil remains relatively unimportant until the fine roots are developed and normal growth can recommence.

In the past artificial fertiliser applications have been aimed mainly at the establishment phase only, e.g. the use of phosphatic fertilisers to encourage root growth (McIntosh, 1984). However, in commercial plantations of conifers it is now widespread practice to apply fertilisers at other strategic stages in growth so as to maximise crop production.

Before planting on a site it is always beneficial to carry out a soil analysis. This will indicate any deficiencies or excesses, and form the basis of a coherent management strategy. Most analyses are based upon ADAS indices; a nutrient level of index 0 being very low, and an index of 3 or 3+ being high. Most soils supply enough nutrients for healthy growth of established woody landscape plants, provided that competition from weeds is minimised. If a nutrient problem does occur it must be identified correctly before remedial action can be taken. In these circumstances, leaf analysis (Binns, Insley & Gardiner, 1983) usually provides more useful information than soil analysis.

The assessment model recognises 4 index levels; these are as follows :

1. Index 0
2. Index 1
3. Index 2
4. Index 3 - 3+

The model provides recommendations for fertiliser applications at the various levels (volume I, Appendix E). Each recommendation is based on ADAS data derived from experiments carried out on the nutrition of nursery stock (MAFF, 1983). In addition to these levels the model also generates a "Soil Textural Note" highlighting the possible problems encountered on modified soils with possible excesses of phytotoxic contaminants.

3.13 ARTIFICIAL PROTECTION

The technique of using treeshelters, i.e. vertical translucent, or transparent plastic structures, round recently planted broad-leaved taxa is now widely practised throughout Britain (Tuley, 1983, Evans & Shanks, 1985, Shanks, 1985). These structures, which are usually 1.2m long, create a favourable micro-climate around plants. They also have the added advantage of providing some protection from rabbits and other pests. Where damage from deer and rabbits is severe it may be advantageous to use plastic net tree guards (Pepper, 1980) which afford greater protection than straight tree shelters.

Tree shelters present a large surface area which can be unstable in exposed localities; because of this it is normal practice to provide some form of staking which will give support to both the plant and the shelter. Research has shown (Patch, 1982) that the use of large stakes on newly planted trees is not always beneficial, and current recommendations are that the minimum size of stake should be used appropriate to the prevailing conditions.

The assessment model recognises two categories relating to the provision of artificial protection, i.e. the use of tree shelters; these are :

1. **No protection given** : The plants are grown without provision of any artificial protection from the elements.

2. **Plant shelters used** : Newly planted taxa are given protection from the elements by the use of a treeshelter with the minimum size of staking system commensurate with the size of taxon and exposure.

The model contains pre-recorded data relating to the provision of artificial protection. However, all initial ratings are set to 1, i.e. no protection given. The settings are used to generate an "Artificial Protection Note" which highlights the benefits of using shelters.

3.14 WEED CONTROL

Weeds have a debilitating effect on plants by competing for light, soil moisture and nutrients. Experiments have shown that the control of weeds around newly planted taxa can produce an increase in both survival rate and subsequent growth (Jones, 1980, Davison & Bailey, 1980, McCavish, 1981).

Various methods of weed control are available, e.g. hoeing, chemical applications and the use of mulches. As long as the material used causes no damage to the ornamental taxa (McCavish & Insley, 1981), the material and the method of application is of secondary importance. What does appear to be critical is the timing and duration of control (Davies & Gardiner, 1987).

The assessment model recognises 4 categories relating to weed control on contemporary landscape sites, these are as follows :

1. **Total weed control** : Some form of weed control is used to maintain a totally weed free planting site, i.e. 1 m^2 at the base of the plant, for the whole year.

2. **Control given after late-June** : Some form of weed control is used to ensure that the site (1 m^2) remains weed free after late-June.

3. **Control given after late-July** : Some form of weed control is used to ensure that the site (1 m^2) remains weed free after late-July.

4. **No weed control given** : The site, i.e. 1 m^2 at the base of the plant, is left unweeded throughout the whole of the growing season.

The model contains pre-recorded data relating to weed control. Initially, all the entries are set to "no weed control given", although the user is at liberty to modify the data at will.

The selected weed control category is used to generate various "Weed Control" notes which highlight the possible reduction in establishment and subsequent growth.

The above listed categories and the assessment model notes which they generate have been based on 2 weed control experiments.

Each experiment was initially carried out to provide accurate data for inclusion in the assessment model. However, the experiments also provide an indication of the enormity of time scale, land, equipment, plant material, cost and commitment necessary to generate accurate data on any individual subject.

To provide suitable data for all areas where contemporary horticultural literature is lacking would necessitate the design and monitoring of experiments on a massive scale, and over a protracted period of time. In certain circumstances this effort could be reduced by extrapolation from known data, but the overall effort required would span many research projects.

EXPERIMENTAL TRIAL TO COMPARE THE ESTABLISHMENT AND GROWTH OF ABIES PROCERA UNDER VARIOUS WEED CONTROL REGIMES.

The competitive effects of ground flora are well proven on most normal landscape sites (Insley & Buckley, 1980). Weeds affect survival rates and growth of ornamental plants, and when present at a critical period, e.g. during the first year after planting, their affects can be dramatic (Davies, 1987).

This trial was intended to provide an indication of the effects which would result from the removal of weed competition at various times of the year.

Methods and materials

Three hundred Abies procera (2+2) plants of USA Oregon provenance, were purchased from a source of known high quality. From this batch 192 plants were visually selected for evenness of shape and size. These were individually weighed and measured and arbitrarily placed in bundles of 12. They were then planted in a randomised block design (4 treatments and 4 replications) with 12 plants randomly allocated per plot, and surrounded by double guard rows. Care was taken to ensure that the plants had the minimum amount of handling and that they were not allowed to dry out. After planting the whole trial was protected from rabbits and hares by the use of 1 metre high, fine-mesh wire fencing.

The trial was planted on the 10th of March, on a free draining open site at an altitude of approximately 1.5 metres above sea level, and a 100% establishment was achieved. The soil type was "NORMOOR" (Lawes, 1983), i.e. a deep stoneless 'Skirt' clay, with a relatively high organic matter content of 8.2%, a pH of 6.8, and an ADAS index of 3+ for phosphorus, potassium and magnesium. The land was ploughed in autumn and just prior to planting was cross-harrowed and firmed with a "Cambridge" roller. The analysis of the soil indicated that no micro-nutrient deficiencies or excesses existed and, therefore, no nutrient remedial treatment was thought necessary.

On the 14th of April Italian Ryegrass was sown, at a rate of 15 grammes per square metre, on 3 of the 4 treatments, the fourth treatment was kept weed free through-out the whole of the trial period. The grass was cut, on average, once per week during the growing season, so as to maintain a height of approximately 25mm.

On the 29th of June of each season the weed competition was chemically removed from one treatment using paraquat. Similarly, on the 27th of July the competition was removed from a second treatment. All weed free plots were kept clear of weeds until the next spring by the use of simazine. This provided the four treatments listed below :

1. No weed competition through-out the year.

2. Weed competition present until the 29th June of each year.

3. Weed competition present until 27th of July of each year.

4. Weed competition present through-out the year.

The same weed competition, i.e. Italian Ryegrass, was provided in the second year, although, as tree growth started early, it was sown on the 14th of March.

Through-out each growing season the plots were monitored on a weekly basis for moisture availability. This was carried out using a moisture metre and 2 soil block sensors per plot. Additional measurements were obtained using a hand held probe. The metre and blocks were manufactured by J.D. Frost of Houston, Texas, and the hand held probe was manufactured by Rapitest.

Results and discussion

Immediately prior to planting the site had an estimated soil moisture deficit (SMD) of between 0mm - 6mm. The SMD figures were supplied by the North Level Drainage Board, Thorney, Peterborough, whose measurements were taken on the same soil type, approximately 500 metres from the trial site. Shortly after planting the weather changed and by the 26th of April a 25mm deficit had built up.

Each plot was measured weekly to ascertain the available soil moisture content. However, the use of the 'Frost' metre with two sensor blocks per plot gave extremely variable results through-out the first season, and it was necessary to supplement the measurements by using a hand held probe. This improved the monitoring considerably, although it did highlight the fact that large intra-plot moisture variation was present. Even so, during periods where a SMD existed, there was a large available moisture discrepancy between weed free and weed infested plots. This reduction was estimated to be approximately 18% on plots containing the Italian Ryegrass as opposed to weed free plots.

The plants with no weed competition established and grew away well in the first year, but those which were subjected to weed competition appeared to be severely checked and produced very limited extension growth. These plants never recovered their vigour and remained stunted through-out the trial period.

The second year of the trial was extremely dry. The trial site had an estimated SMD of 23mm in January, rising to 108mm in August - the estimated deficit remained above 60mm until the middle of December. The dryness of the season resulted in extremely poor Italian Ryegrass establishment, and it was necessary to allow a 'Tumble-down' cover to establish in order to give adequate competition.

At the end of the trial all living plants were removed and measured. Statistical analysis (ANOVA) of the data (volume I, Appendix F) was carried out at Rothamsted Experimental Station using a MicroVAX 3600 running VMS V5.1a on Agrenet node IACRAD. The results are summarised in table 1 below.

Table 1.

Summary of Abies procera weed competition experiment

Treatments	1	2	3	4	SED
Initial Wts.(grms)	20.0	19.4	19.2	19.1	0.59
Final Wts.(grms)	61.9	30.7	23.6	22.0	1.86
Initial Hts.(mm)	122.5	121.8	119.4	124.3	3.34
Final Hts.(mm)	190.4	155.4	138.4	136.5	5.62
df = 9					
% Survivors	98	90	81	75	2.80

Initially there were no significant differences between the heights or weights of the plants receiving the treatments, but at the end of the experiment these were large.

The results show that plants which remain weed free through-out the first two years after planting exhibit a large increase in growth and survival rate as compared to the other treatments. Similarly, plants which remain weed free from the 29th of June onwards in the first two years show a large increase in growth and survival as compared to treatments 3 and 4. However, the results also lead to the conclusion that in a practical situation little benefit would be obtained from controlling weeds after the end of June.

EXPERIMENTAL TRIAL TO COMPARE THE ESTABLISHMENT AND GROWTH OF CRATAEGUS MONOGYNA UNDER VARIOUS WEED CONTROL REGIMES.

This trial was intended to provide an indication of the effects which would result from the removal of weed competition from the base of **Crataegus monogyna** at various times of the year.

Methods and materials

Three hundred multi-branched **Crataegus monogyna** plants were purchased from Baytree nurseries, near Spalding, Lincolnshire. From this batch 144 plants were visually selected for evenness of shape and size. These were individually weighed and arbitrarily placed in bundles of 12. They were then planted in a randomised block design (4 treatments and 3 replications) with 12 plants randomly allocated per plot, and surrounded by double guard rows. Care was taken to ensure that the plants had the minimum amount of handling and that they were not allowed to dry out.

The trial was planted on the 12th of March, on the same site as the **Abies procera** experiment, and the same 4 treatments were applied. The plants were protected from rabbits and hares by the use of fine-mesh wire fencing, and a 100% establishment rate was achieved.

The same weed competition as the **Abies procera** experiment, i.e. Italian Ryegrass, was provided in both years, although in the second year tree growth started early, and it was necessary to sow the seed on the 14th of March instead of in April.

Through-out each growing season the plots were monitored on a weekly basis for moisture availability. This was carried out using the same equipment as in the **Abies procera** experiment.

Results and discussion

The comments relating to the monitoring of moisture in the **Abies procera** experiment are relevant to this experiment also.

At the end of the trial all living plants were removed and weighed. Statistical analysis (ANOVA) of the data (volume I, Appendix F) was carried out at Rothamsted Experimental Station using a MicroVAX 3600 running VMS V5.1a on Agrenet node RESA. The results are summarised in table 2 below.

Table 2

Summary of Crataegus monogyna weed competition experiment

Treatments	1	2	3	4	SED
Initial Wts.(grms)	22.9	21.0	23.6	23.1	0.9
Final Wts.(grms)	62.7	38.9	35.3	32.6	2.5
df = 6					
% Survivors	97	94	83	61	6.4

Initially there were no significant differences between the weights of the plants receiving the treatments, but at the end of the experiment these were large.

The results show broad similar effects of weed competition to those found in the **Abies procera** experiment, i.e. that plants which remain weed free through-out the year show a large increase in growth and survival rate as compared to the other treatments. Similarly, plants which remain weed free from the 29th of June show an increase as compared to treatments 3 and 4, but that this is not as large as with **Abies procera**. The results suggest that in a practical situation little benefit would be obtained from controlling weeds after the end of June.

3.15 ARTIFICIAL IRRIGATION

The factors which affect decisions on when to water ornamental taxa, and how much water to apply are climate, soil type, site characteristics, plant response and economics (Hall, et al, 1977). Irrigation is expensive and to obtain the best results careful pre-planning is essential. On soils which are retentive of moisture it is common practice to ignore artificial irrigation altogether, or satisfy only part of the water requirement, i.e. maintain a small moisture deficit. This type of system allows flexibility, especially during sporadic dry/showery periods (MAFF, 1982). On sites with poor moisture retentive properties some form of artificial irrigation coupled with additions of organic materials and mulches may be necessary to increase establishment to an acceptable level.

The assessment model allows the selection of two irrigation regimes based on W.H. Hogg's irrigation plan No. 3 (MAFF, 1967). The two regimes are as follows :

1. No artificial irrigation;
2. 25mm of water applied when a 75mm SMD exists.

The selection of either of the above regimes in conjunction with climatic and site related features is used to generate a series of guideline "Irrigation" Notes. Initially the model is pre-programmed for no artificial irrigation, although the user is at liberty to modify the regime at will.

EXPERIMENT 1 TO SHOW THE VARIABILITY OF GROWTH UNDER VARIOUS MOISTURE REGIMES.

This experiment was intended to provide an indication of the effects on **Abies procera** (2+1 transplants) from 4 different moisture regimes.

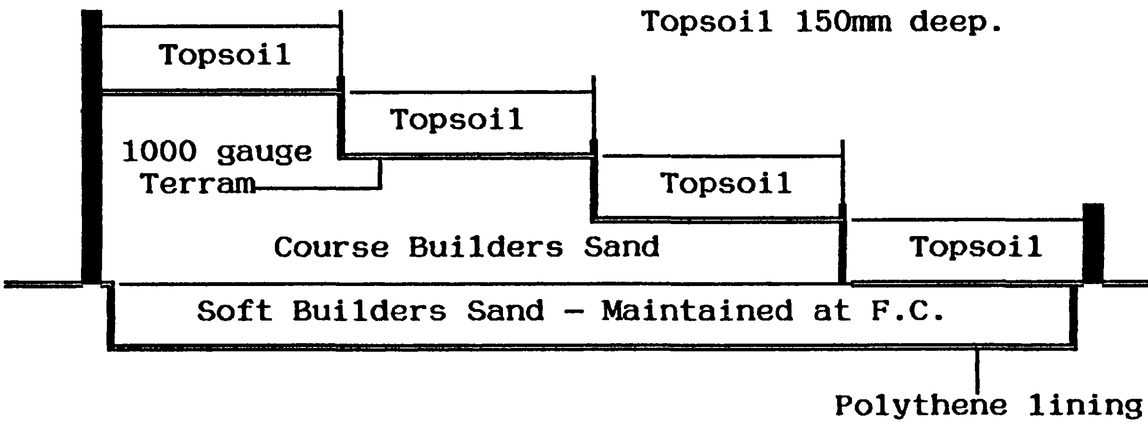
Methods and materials

One hundred **Abies procera** (2+1) plants of USA Oregon provenance, were purchased from a source of known high quality. From this batch 64 plants were visually selected for evenness of shape and size. These were individually measured and arbitrarily placed in bundles of 16. They were then planted in 4 blocks with 16 plants randomly allocated per block. Care was taken to ensure that the plants had the minimum amount of handling and that they were not allowed to dry out.

The trial was planted on the 10th of March, 1988, on a 4 tier bed construction (see Figure 3). The bed was situated on an open site at an altitude of approximately 1.5 metres above sea level, and a 100% establishment was achieved.

The soil type was "NORMOOR" (Lawes, 1983), i.e. a deep stoneless 'Skirt' clay, with a relatively high organic matter content of 8.2%, a pH of 6.8, and an ADAS index of 3+ for phosphorus, potassium and magnesium. The analysis of the soil indicated that no micro-nutrient deficiencies or excesses existed and, therefore, no nutrient remedial treatment was thought necessary.

Figure 3. Cross section of the Water-bed construction



Basal area filled with "soft" builders sand, i.e. standard brick-laying quality, and maintained at field capacity by means of an automatic cistern and hose pipes.

1000 gauge terram sheeting laid to allow moisture movement but prevent roots penetrating into the sand.

The plants were allowed to become established within the beds and on the 1st of June 1988 the water was turn on to flood the basal area. The lowest bed was maintained at field capacity for the duration of the experiment. The soil moisture status was assessed indirectly by electrical resistance of gypsum blocks (see Abies weed control experiment above), the 4 average available moisture contents were as follows :

field capacity;

21% below FC;

40% below FC;

64% below FC.

Results and discussion

At the end of the trial all living plants were removed and measured. Statistical analysis (ANOVA) of the data (volume I, Appendix F) was carried out at Rothamsted Experimental Station using a MicroVAX 3600 running VMS V5.1a on Agrenet node RESA. The results are summarised in table 3 below.

Table 3

Summary of Abies procera water regimes experiment

Treatments	1 64%	2 40%	3 21%	4 F.C	SED*	DF
Initial Hts.(mm)	73	71	77	78	4.0	60
Year 1 Hts.(mm)	113	120	124	121	6.8	58
Year 2 Hts.(mm)	182	201	195	173	10.9	58

* Based on the variation between trees within the plots.

The differences were not formally significant at the 5% level, but the intermediate beds, i.e. beds 2 and 3 show some advantage.

The size of the experimental bed, its complexity and cost of construction, restricted the number of treatments and replications. This meant that there are no valid errors because of the lack of replication. However, if we look at the initial, pre-treatment heights there are no significant differences between plots compared with variation from tree to tree within the plots. It could be argued, therefore, that if subsequent differences arose these would be due to the treatments. The experiment using part of the same bed construction, only with **Fraxinus excelsior** seedlings also gives credence to this argument. It is acknowledged that the experiment gives only a broad indication of the effects of the treatments, and that a larger replicated experiment would be necessary before accurate results could be obtained.

EXPERIMENT 2 TO SHOW THE VARIABILITY OF GROWTH UNDER VARIOUS MOISTURE REGIMES

This experiment was intended to provide an indication of the effects on **Fraxinus excelsior** seedlings from 4 different moisture regimes.

Methods and materials

Two hundred seedlings of **Fraxinus excelsior**, were collected from a local source. From this batch 120 were visually selected for evenness of shape and size. They were then planted in 4 blocks with 30 seedlings randomly allocated per block. Care was taken to ensure that the plants had the minimum amount of handling and that they were not allowed to dry out.

The trial was planted on the [illegible] [illegible] [illegible]il, 1988, on the same 4 tier bed construction as experiment 1 above (see Fig. 3), and a 100% establishment was achieved.

Results and discussion

At the end of 2 years all living plants were removed and measured. Statistical analysis (ANOVA) of the data (volume I, Appendix F) was carried out at Rothamsted Experimental Station using a MicroVAX 3600 running VMS V5.1a on Agrenet node RESA. The results are summarised in table 4 below.

Table 4

Summary of Fraxinus excelsior water regimes experiment

Treatments	1 64%	2 40%	3 21%	4 F.C	SED*	DF
Yr. 1 Hts.(mm)	67	97	151	112	3.6	116
Yr. 2 Hts.(mm)	252	287	408	336	24.1	116

* Based on the variation between trees within the plots.

If the differences between beds and variation between trees within beds is tested, there are large significant differences between beds at year 1 and

2, although these might be due to factors other than the applied treatments. However, the results are consistent with beds 3 and 4 being better than beds 1 and 2.

In this experiment the differences are highly significant when judged against the variation within the plots. If we assume that the site for this experiment had similar characteristics as experiment 1 above, i.e. it was the same bed construction and the same time scale, it seems reasonable to conclude that these large differences were caused by the treatments and that regime 3 was superior to the rest.

4.0 ADVISORY NOTES AND RECOMMENDATIONS

Once a location has been selected and any necessary modifications to climate, soil and site parameters have been made, the model will generate a series of advisory notes and recommendations (volume I, Appendix E). The individual notes indicate potential difficulties relating to all aspects of the site, whereas the recommendations suggest ways of improving establishment and growth.

The model contains a total of 53 notes and recommendations, ranging from 2 lines of altitude related text, to 34 lines of individual fertiliser recommendations. However, only a sub-set of the total is generated for any specific location. The following list outlines the individual subject areas which are covered, and the inter-relationships, such as coastal proximity and exposure, which are used to generate specific notes.

<u>Note and Recommendation Topics</u>

Altitude above 120m.

Altitude above 375m but below 670m.

Altitude above 670m.

Altitude plus exposed site.

Altitude plus severely exposed site.

Altitude plus sheltered site.

Coastal proximity with shelter.

Coastal proximity without shelter.

Exposure but less than 375m.

Exposure but greater than 375m.

Exposure plus coastal proximity.

Very exposed sites.

Soil textural group.

Soil textural group and soil structure.

Soil depth.

Drainage characteristics.

Groundwater effect.

Slope.

Possibility of erosion.

Soil structure.

Presence of soil pans.

Soil pH rating.

Organic matter content.

Calcium carbonate content.

Soil nutrient status.

Artificial protection.

Weed control.

Artificial irrigation.

The information contained in each of the notes and recommendations has been been collated from a wide range of climatological and horticultural sources, although wherever possible it has been derived from the same authorities as used for selecting the initial micro-climatic, soil and site adjustments options.

5.0 PLANT INTOLERANCES

The performance of ornamental taxa used in the general landscape is adversely affected by abnormal variations in both climate and soil. For example, street tree growth is often restricted by exposure to a variety of environmental stress factors, such as soil moisture deficits, wind channels and vehicle exhaust emissions (Bassuk & Whitlow, 1988). Similarly, unprotected plants grown in exposed conditions, frequently produce malformed, stunted growth, due to physical buffeting and excessive transpiration demands (Robertson, 1987).

Not all abnormal variations of climate and site will necessarily produce distinct symptoms in all taxa; some plants are better adapted to withstanding adversity than others. The assessment model has been developed to allow the identification of taxa which are intolerant of the climatic, site and soil conditions listed below.

<u>Plant intolerance criteria.</u>

Soil texture.

Soil depth.

Soil moisture.

Soil pH.

Maritime conditions.

Site exposure.

Late spring frosts.

Seasonal waterlogging.

Within the model each of the above categories is sub-divided to allow individual plant intolerances to be identified. During data input taxa are "Tagged" to highlight specific requirements. Those capable of establishing and growing in a wide range of situations are tagged as being "Undemanding", and where no data are available the taxa are tagged accordingly.

5.1 SOIL TEXTURE

The assessment model allows the selection of either of the following categories :

1. clay/clay loams;
2. sand/sandy loams.

The two generalised types of soil have been selected for inclusion in the model because when incorrectly managed, or located in high or low rainfall areas, both may exhibit extreme growing conditions. Poorly structured clays, for example, become hard and cracked when dry, but are sticky and difficult to work when wet (Older, 1983). Sandy soils, on the other hand, are typically well drained or excessively well drained, and low in nutrients (McGourty,1982).

Whenever a taxon is selected which is intolerant of either of the above categories the model will generate one of the following corresponding notes :

1. High clay content soils.
2. High sand content soils.

5.2 SOIL DEPTH

Shallow soils, especially those overlying impervious subsoils, restrict root activity and have a tendency to dry out quickly during the growing season. The assessment model allows the identification of taxa which are intolerant of shallow soils. The following soil depth category is recognised :

1. Shallow soil.

Whenever a taxon is selected which is intolerant of shallow soil conditions the model will generate the following corresponding note :

1. Shallow soil conditions.

5.3 SOIL MOISTURE

A number of soils in England and Wales have a very low water-holding capacity, which can lead to the development of large soil moisture deficits during the growing season. These deficits, which can be estimated accurately, (Bibby et al, 1982) severely restrict the range of taxa capable of successful establishment and growth.

Soils, e.g. clays, which are slowly permeable or have slightly impeded drainage, release their moisture over a relatively long period of time. Certain taxa are intolerant of these moisture regimes and either fail to establish, or produce minimal amounts of extension growth.

The assessment model contains the following soil moisture intolerance categories :

1. Dry soils.
2. Wet soils.

Whenever a taxon is selected which is intolerant of either of the above categories the model will generate one of the following corresponding notes :

1. Dry soil conditions.
2. Wet soil conditions.

5.4 SOIL pH

The majority of landscape taxa are capable of growing in a broad range of pH. However, certain plants are unsuccessful when grown in either highly acidic, or alkaline conditions. The assessment model contains the following two categories of pH intolerance :

1. Low pH.
2. High pH.

Whenever a taxon is selected which is intolerant of either of the above categories the model will generate one of the following corresponding notes :

1. Low pH - Acidic conditions.
2. High pH - Alkaline soil.

5.5 MARITIME CONDITIONS

Plants vary in their ability to grow in close proximity to the coast. Some, e.g. **Griselinia spp.** establish with little or no protection, whereas others, e.g. **Abelia spp.** can be killed outright, even when afforded some shelter. The assessment model recognises the following maritime intolerance category :

1. Intolerant of coastal proximity.

Whenever a taxon is selected which is intolerant of coastal proximity the model will check the exposure rating of the site, and then generate one of the following corresponding notes :

1. Exposed coastal site.

2. Unexposed coastal site.

5.6 SITE EXPOSURE

Exposed planting sites, especially those in close proximity to coastal regions, or at altitude, can severely restrict the establishment and subsequent growth of plants. The storm of 1987 (HMSO, 1988) which swept across southern England, has shown that extensive damage from strong winds can occur, even in relatively sheltered locations. The assessment model recognises the following exposure intolerance categories :

1. intolerant to all but very sheltered conditions;
2. intolerant to all but sheltered conditions;
3. intolerant to exposed conditions;
4. intolerant to extreme exposure.

Whenever a taxon is selected which is intolerant of one of the above categories the model will generate the following corresponding note :

1. Not enough shelter given.

5.7 LATE SPRING FROSTS

The greater part of mainland England and Wales encounters temperatures below freezing point. Fortunately for the horticulturalist, the majority of these occur during the winter months when plants are dormant. However, when low temperatures coincide with growth, e.g. fruit tree blossom or the development of young tender shoots, much damage can result. The assessment model recognises the following late spring frost intolerance category :

1. intolerant of late spring frost.

Whenever a plant is selected which is damaged to some extent by late spring frosts, e.g. Camellia blossom, the model will generate the following corresponding note :

1. possible late spring frost.

5.8 SEASONAL WATERLOGGING

Soils which are subject to regular flooding, or seasonal saturation of the root zone, can affect plants adversely. In these circumstances soil air is replaced by water, and anaerobic conditions which are inconducive to root survival, ensue. In addition, a physiological barrier to root growth exists which increases the risk of windthrow (Macaulay et al, 1988). The assessment model recognises the following intolerance category :

1. Intolerant to seasonal waterlogging.

Whenever a taxon is selected which is intolerant of seasonal waterlogging the model will generate the following corresponding note :

1. possible waterlogging.

5.9 PLANT INTOLERANCE DATA

The most difficult component in the development of any computerised predictive model is the acquisition of suitable data. Previous research into plant selection databases (Hitchmough, 1984a, Hope 1986a) has highlighted the inadequacy of current taxon-based information systems, but unfortunately little, if anything, has been done to correct the situation.

The University of Bath assessment model contains a data-file of all the plants in the Joint Council of Landscape Industries recommended plant list (JCLI, 1978). Each plant has been given a rating corresponding to the eight intolerance categories described above (see 5.0 above and volume II, Appendix D).

The major problem which currently exists is that little systematic research has been carried out, on decorative taxa, to quantify the effects of specific intolerances. Traditionally a simplistic approach, using terms such as "Satisfactory", "Satisfactory if Husbanded" and "Unsatisfactory" (Hitchmough, 1984a) has been followed. This type of assessment is of restricted value when attempting to develop an accurate predictive model.

The inadequacy of current literature in relation to plant intolerances has meant that much of the University of Bath assessment model data are, by necessity, highly subjective, and are mainly based on growth within the traditional garden, rather than the contemporary landscape. The data for individual plants were collated from an extensive range of horticultural literature, botanic garden databases, plant surveys, nursery catalogues, plant selection databases and the experience of the author. This method will undoubtably have lead to some inaccuracy in the plant assessments, although until a more scientific method of data acquisition is available, the current situation will remain.

6.0 ASSESSMENT OF PLANT HARDINESS

An accurate assessment of plant hardiness is an extremely difficult objective to achieve, due mainly to the fact that no generally recognised definitive definition exists (see section 1.5 - Modelling of plant related climatic features).

For the purposes of the current research project, a plant is considered to be "frost hardy" on a site, if it is capable of establishment and growth, in all but 10 year extreme winters, i.e. plants capable of survival in climatic zones 7 to 14 of James Hitchmough's "Climatebase" model (Hitchmough, 1984a). It is recognised that in certain circumstances some minor frost damage may occur, however, this is ignored if the plant can recover to produce an acceptable specimen.

The assessment of plant hardiness has been based on the Meteorological Office's Accumulated temperatures below zero degrees centigrade (Smith 1984), with micro-climatic adjustments for coastal proximity and exposure each equating to 1 of James Hitchmough's winter cold zones, i.e. 40 day degrees below zero degrees centigrade.

Hitchmough based his hardiness assessments on a plant-orientated numeric system which, because of the subjectivity of survey derived data, proved to be inaccurate at altitude and in very sheltered locations. The current assessment model is climate, site and plant orientated which provides greater flexibility, especially in abnormal locations.

The use of mean day-degree temperature calculations does not take into account the large fluctuations which can arise on individual sites, although the use of climatic correction factors does improve the accuracy of predictions. During the testing phase of the assessment model it was found that very sheltered sites close to the coast, e.g. Ness Gardens in the Wirral, produced inaccurate predictions. To alleviate this inaccuracy it was found that an additional correction factor equating to 25% of one of Hitchmough's cold zones needed to be subtracted from the day-degree totals.

The current assessment model contains a data-file of approximately 1,000 taxa which are generally recognised as being damaged by low temperatures in either average, or ten year extreme winters (volume II, Appendix C). The file has been based on Survey derived data (Hitchmough, 1984a), but has been expanded upon by use of general horticultural literature. The comments made relating to the data on plant intolerance (see 5.9 above) are considered relevant to the "Tender-plant" data-file.

DISCUSSION

The use of micro-computers in commerce and the home is now widespread, with few people being able to conduct their lives without being affected in some way by their use. This is remarkable when one considers that the very first systems only became commercially available in the mid to late 1970's. Since those early days computer hardware and software technology has developed at such a frenetic pace that machines and programmes which were developed only three or four years ago are now, in many cases, redundant.

In such volatile conditions it is almost impossible to forecast the route which computer technology will follow. Since IBM has become the dominant force in the industry, the pace of development does appear to have slowed down somewhat, although many critics would argue that IBM's dominance has merely stifled new ideas.

Although there is still immense volatility in the market a number of consistent trends have become apparent. Firstly, more sophisticated micro-processors are constantly being evolved, with an ever increasing number of functions and greater speed of operation. Secondly, available storage capacity, and the speed of data retrieval are both increasing. Thirdly, although recently introduced processors and data storage devices appear expensive, in real terms prices are either remaining static, or actually falling. This means that although "state of the art" technology remains costly, older, more tried and tested hardware is relatively inexpensive.

One of the major problems with micro-computers in the past has been the degree of incompatibility between individual manufacturers' machines. Since the advent of the IBM PC, this problem has become less important as almost all companies now attempt to obtain some degree of compatibility with IBM systems. Nevertheless incompatibilities do still exist, which effectively reduces the use of certain types of software.

The initial choice of hardware is critical in the development of any worthwhile research model. It is extremely frustrating for software developers to spend a number of years designing programmes, only to find that when complete a specific machine is timeworn and the software is unavailable to other users. In the early 1980's programmers needed to be almost clairvoyant when selecting their hardware, although more recently their dilemma has become less intense. The reason for this is that many programmers are now loath to carry out software development on new hardware until it has an established position in the market, and even then they ensure that the programmes are in an easily maintainable form.

The current research model was originally developed on an industry standard machine. The hardware, although not "state of the art" was widely available at reasonable cost, and had been found to be extremely reliable. This meant that the model could be used on an extensive range of machines and would hopefully be upward compatible with INTEL's most modern microprocessors. It was felt that this would ensure that any further work on the model would be of an enhancing nature, and not just the tedious toil necessary to simply convert it to run on another system.

The initial choice of the Victor V286C computer for the research project has proven to be correct. The INTEL 80286 microprocessor is still one of the industry standards and is fully compatible with the vast majority of modern equipment.

The development of software, such as disc operating systems, programming languages and application programmes, is following the same broad route as computer hardware. Programmes are becoming more sophisticated, whilst the pricing structure remains comparatively static. Standardisation of programming languages, such as the new ANSI code for "C", and a greater compatibility between integrated software packages, is becoming the norm. This should mean that future generations of software will be easier to develop, learn and use.

The "C" programming language was used in the development of the University of Bath model so that little if any modification would be necessary to the "Source Code" before it could be transferred to other machines. The choice of the "C" language was made for a number of reasons. Initially it was selected because it was rapidly becoming the industry standard language. As the model was a "first attempt" it was felt that anyone capable of making advances in the model's design would almost certainly be capable of programming in "C". At the present time this assumption is probably incorrect, although within the next two to three years it will almost certainly be the case.

When micro-computers first became available there was a massive amount of interest in computer programming. One of the main reasons for this was the introduction of BASIC, which allowed the general public to develop meaningful software. Today most of the initial interest has waned, and what horticulturally related programming effort still exists now appears to be based around the use of commercial databases. The probable reason for this is that databases allow the user to obtain standard database management systems with the minimum of programming knowledge, and in the shortest possible time. Unfortunately, they do not allow the flexibility of purpose designed programmes.

The major obstacle to further development of the University of Bath assessment model will not rest solely on the ability of a researcher to computer programme in a specific language. Fundamentally, the problem will be to find someone with both adequate programming and horticultural expertise. Looking at the current state of horticultural computer programming this will be no easy task, and in the short term, further development will probably rest with the current author. This statement is rather contentious, but it can be validated by simply attempting to list all currently available specific amenity horticulture software programmes. To the authors knowledge, other than plant selection programmes, none exist.

The design and production criteria of a model suitable for use by specialist horticulturalists, or landscapers is totally different to one designed for research use only. Researchers are usually more concerned with the final results of computations, rather than easily read display screens, or the ease of use of a particular programme. Professional horticulturalists, on the other hand, usually require programmes which are easy to use, free from errors and produce reliable well illustrated information from pre-recorded data. This last point is crucial, as the majority of people will only use a model if it is pre-programmed with all the data necessary to run it. Few people will use a model if they have to compile their own information first.

Even though micro-computers have been available for a relatively long time there are still people who look upon them and their potential usage with broad scepticism. This is especially so where data relating to ornamental taxa are concerned. Some people either fear that such systems will remove the need for their personal degree of expertise, or simply believe that the whole subject is far too complex for an accurate working model to be developed. There even appears to be a belief among amenity horticulturalists that our present understanding of the biology and husbandry of amenity plants is sufficient. **What they fail to comprehend is that models will not replace their skills, but merely enhance their knowledge and performance.**

Computer models stand or fall on the data which they contain. If for any reason these are inaccurate they will result in incorrect results and perpetuate bogus information. Much of the current understanding relating to plants has been passed on from generation to generation, with little if any systematic research being carried out. Until such work is initiated to cover a wide range of taxa any plant-based computer model will be inadequate, and of limited use.

The majority of climatic data used in the University of Bath assessment model have been collated from the Meteorological Office records for England and Wales, which are arguably the most comprehensive in the world. Unfortunately, even organisations as large as this have financial restraints placed upon them, which effectively prevents them from producing fully authoritative publications. This was highlighted when Technical Bulletin No. 35 was re-issued as a re-print with minor modifications, rather than the more desirable full revision. Similarly, records for such parameters as "coastal effect" are rather inaccurate in the sense that data have been obtained by extrapolating from a relatively small number of sites. Nevertheless, these data are the most accurate available.

Having produced a model which illustrates a range of climatic related features the natural progression would be to allow individual users to input current information, i.e. on a daily, weekly or monthly basis. This is a possibility, as many areas in the country have suitable recording stations and the various networks for disseminating the data, e.g. MORECS, already exist.

The specific data relating to the soil and site parameters for the assessment model have been based largely on the work of the Soil Survey of England

and Wales. Their information, and how it is presented, is of the highest quality and it is difficult to imagine how it can be improved upon. The only area of concern influencing the computer model is that the soils of large conurbations have frequently been manipulated to such a degree that data relating to them are of limited value, purely because these soils are in effect "man made". This in no way detracts from the usefulness of the available data, but merely highlights a situation which is outside the scope of the Soil Survey of England and Wales.

A natural progression to the existing model would be to develop it to a point that provides users the facility of interactively inputting soil analysis and soil toxicity data. This would then allow the model to relate more directly to contemporary landscape planting, as well as the more traditional sites. It would also have the major advantage of drawing the model closer to the point of being capable of making actual seasonal predictions of growth.

There are true growth models in existence, for example in forestry and agriculture, which predict specific aspects of plant growth. However, these are normally only used to produce an indication of growth in relation to economics of crop production, rather than estimates of decorative ornamental performance. None of these models have been designed to give guidance in note form of the interactive selection and manipulation of climatic, site, soil and taxon related information; in this context the current research model is unique.

When developing a performance related growth model for decorative taxa it must be recognised that opinions of what is an acceptable performance will vary considerably. Unlike commercial crops it is nonsensical and counter-productive to attempt to place economic values on ornamental plant attributes. In reality, the sensible route is to build up an extensive database of informative notes which can be used as suitability guidelines. Once such a database is available then the work on a true amenity growth model can begin.

The University of Bath assessment model has been developed around the concept of using guidance notes and recommendations to aid in the management of a site and its subsequent planting. Initially 53 notes and recommendations have been stored, so that multiple criteria analysis can be used to generate helpful comments and recommendations. The possible total number of notes and recommendations is dependent solely on the amount of available disc storage capacity, which means that for all practical purposes no limit exists. There are also no limits regarding the complexity of the criteria analysis, which means that highly complex inter-relationships and concepts can be introduced.

The selection of criteria for inclusion in an assessment model is extremely difficult as each potential user of the system will have different requirements. For example, landscape architects require totally different information as compared to botanic garden staff, or students. As all of these groups are potential users of the model it follows that encoding all data required by them would be a massive task. However, the author considers that the current model is a sound basis on which this work could be based.

The current research has attempted to outline a template for the eventual development of a climatic, landscape and taxon-based model. As a first attempt it appears to have been successful, although a considerable amount of further work in both computer programming, and data collation would be necessary before it could be turned into a stand alone working system. The model has been produced in the most flexible way to allow new ideas and data to be easily included. It now only remains to be seen if the concept of such a model is stimulating enough to encourage further work on the subject.

REFERENCES

Advisor. (1986). ADAS Advisor No. 57. January 1986.

Amerine, U.A. & Winkler, A.J. (1944). Composition and Quality of Musts and Wines of Californian Grapes. Hilgardia 15 493675.

Ashton-Tate (1989). Dbase IV User Manual. Ashton-Tate, Culver City, USA.

Atkinson D. and Ofori-Asamoah, T.E. (1987) The growth of the nursery root system and its influence on tree performance after transplanting. In. Advances in practical arboriculture. Bulletin 65. Forestry commission. Edinburgh.

Austin R.B. (1984). A Study of the Growth And Yield of Carrots in a Long-term Manurial Experiment. J.Hort. Science. 1963. p.38.

Avery, B.W. (1980). Soil Classification for England & Wales. (Higher Categories).

Baker, H. (1986). The Fruit Garden Displayed. The Royal Horticultural Society. Cassell Ltd, London.

Barden, W. Jr. (1980). TRS-80 Assembly-Language Programming. Radio Shack, Fort Worth, Texas, USA. p.19.

Barr, P.C., Krimper, R.L., Lazear, M.R., Stammen, C. (1985). CAD Principles and Applications. Prentice-Hall, Inc., Englewood Cliffs, NJ 07632.

Bassuk, N. & Whitlow, T. (1988). Environmental Stress in Street Trees. Arboricultural Journal 1988. Vol.12, pp.195-201. AB Academic Publishers., Gt. Britain.

Beckjord, P.R. & Cech, F.C. (1980). Effects of Various Methods of Root Pruning on the Establishment of Transplanted Red Oak Seedlings. Tree Planters Notes. 31 (4). pp.10-11.

Bendelow, V.C. & Hartnup, R. (1980). Climatic Classification of England & Wales. Soil Survey, Technical Monograph. no.15. Harpenden, Hertfordshire.

Bibby, et al. (1982). Land Capability Classification for Agriculture. Soil Survey of Scotland Monograph, Macaulay Institute for Soil Research, Aberdeen,

Bickmore, C.J. & Hall, T.H.R. (1983). Editors of: Computerisation of Tree Inventories. A.B. Academic Publishers 1983.

Binns, W.O. (1975). Fertilisers in the Forest : A Guide to Materials. Forestry Commission Leaflet No.63. HMSO, London.

Binns, W.O. (1983). Establishing Trees on Damaged Soils. Tree Establishment Symposium. University of Bath 1983. pp.32-39.

Binns, W.O., Insley. H,. & Gardiner, J.B.H. (1983). Nutrition of Broadleaved Amenity Trees.

Arboriculture Research Note 50/83/SSS, Forestry Commission, Alice Holt Lodge, Farnham, Surrey.

Birse, E.L. (1971). Assessment of Climatic Conditions in Scotland. 3. The Bioclimatic Sub-regions. Macaulay Institute : Soil Survey of Scotland.

Birse, E.L. & Dry, F.T. (1970). Assessment of Climatic Conditions in Scotland 1. Macaulay Institute, Soil Survey of Scotland.

Birse E.L. & Robertson, L. (1970). Assessment of climatic conditions in Scotland 2. Based on Exposure and Accumulated Frost. Macaulay Inst. : Soil Survey of Scotland.

Bleasdale, K.K.A. (1973). Plant Physiology in Relation to Horticulture. Macmillan, London.

Borland (1988). Turbo C Vers.2. Borland International (UK) Ltd. Berkshire.

Caborn, J.M. (1965). Shelterbelts and Windbreaks. Faber & Faber, London.

Cain, C. (1989). Not All Quiet on the Archie Front. Personal Computer World. November 1989. Vol.12. No.11. p.241.

Capel, J.A. (1980). The Establishment and Growth of Trees in Urban and Industrial Areas. Ph.D. thesis. University of Liverpool, 1980.

Chandler, T.J. & Gregory, S. (Eds) (1976). The climate of England and Wales. Longman, London.

CIBS. (1979). CIBS Guide A 6. Solar data. London.

Clayden, B. & Hollis, J.M. (1984). Criteria for Differentiating Soil Series. Soil Survey Technical Monograph, No. 17. Harpenden.

Clifton, C. (1986). Pers. Comments. (Educational Software Manager, Sinclair Research Ltd. Cambridge).

Coffron, J.W. (1983). Programming the 8086-8088. Sybex Inc, Berkeley, California 94710. p.52.

Computer Shopper (1989). Back to Basics. Computer Shopper, April 1989, No.14, p.32.

Cooke, G.W. & Williams, R.J.B. (1974). Problems with Cultivations and Soil Structure at Saxmundham. Report. Rothamsted Experimental Station. 1971(2). pp.122-142.

Corbett, W.M. & Tatler, W. (1970). Soils in Norfolk : Sheet TM 49 (Beccles North) Soil Survey. Rec. No.1.

Cousens R. (1987). Theory and Reality of Weed Control Thresholds. Plant Protection Quarterly. Vol.2(1) pp.134-20. 1987.

Curtis, L.F., Courtney, F.M. & Trudgill, S.T. (1976). Soils in the British Isles. Longman, London.

Daly M. (1982). UKF T•-Sum. The Guide to More Early Grass. UKF Fertilisers Ltd. Ince, Chester.

Daly M. (1982/3). The T•-Sum System of Timing Nitrogen for Spring Grass. University College of Wales. Journal of the Agricultural Society 1982/83. Vol. 63. pp132-149.

Davis, R.J. & Gardiner, J.B.H. (1987). The Effects of Weed Competition on Tree Establishment. Forestry Commission Arboricultural Note 59/87/ARB. Forestry Commission, Alice Holt Lodge, Wrecclesham, Surrey.

Davis, R.J. (1987a). Do Soil Ameliorants Help Tree Establishment? Arboriculture Note 69/87/SILS, Forestry Commission, Alic Holt Lodge, Farnham, Surrey.

Davies, R.J. (1987b). Trees and Weeds. Forestry Commission Handbook 2. HMSO, London.

Davison, J.G. & Bailey, J.A. (1980). The Effect of Weeds on the Growth of a Range of Nursery Stock Species Planted as Liners and Grown for Two Seasons. Proceedings Weed Control in Forestry Conference, 1980. pp.13-20.

Deen, S.M. (1985). Principles and Practice of Database Systems. Macmillan, London. p.8.

Doyle C.J., Cousens R., & Moss S.R. (1986). A Model of the Economies of Controlling Alepocurus myosuroides in Winter Wheat. Crop Protection (1986), 5 (2), pp.143-150.

Edwards P.N. & J.M. Christie (1981). Yield Models for Forest Management. Forestry Commission Booklet number 48.

England R.A. (1985). Modelling the Performance of Spray Decision Rules for Cereal Crops: 1. The Host Crop. NIAE - Crop Engineering Division, November 1985. Divisional note No. 1301.

Evans, J. & Shanks, C.W. (1985). Treeshelters. Arboriculture Research Note 63/85/SILS. Forest Research Centre, Alice Holt Lodge, Farnham, Surrey.

.Exe. (1986). Softclone. Compatibility without compromise. Exe. Computer magazine. March 1986. 1,(2). pp. 13-16.

.Exe. (1989). Clipper Libraries. Exe. Computer Magazine. September 1989. Vol 4. Issue 4. pp. 60-64.

Fairburn, W.A. (1968). Climatic Zonation in the British Isles. Forestry 41, pp.117-130.

Forestry Commission (1957). Exotic Forest Trees in Great Britain. Forestry Commision Bulletin No. 30. HMSO, London.

Freeman, R. (1983). Beyond BASIC. 6502 Assembly Language Programming for the British Broadcasting Corporation Micro-computer. British Broadcasting Corporation, London.

Geiger, R. (1959). The Climate Near the Ground. Harvard University Press, Cambridge, Mass.

George, D.J. (1963). Temperature Variations in a Welsh Valley. Weather 18. pp.270-274.

Gilbertson, P. and Bradshaw, A.D. (1985). Tree Survival in cities : the Extent and Nature of the Problem. Arboricultural Journal 9(2). pp.131-142.

Gottfried, B.S. (1975). Programming With BASIC. McGraw-Hill Book Company, London. p.199.

Grace, J. (1987). Water Relations and Irrigation Methods for Trees. In Patch, D. (Ed) Advances in Practical Arboriculture. Bulletin 65. Forestry commission. HMSO. London.

Greenwood, W.E. (1988). Clipper Isn't as Quick as you Think. P.C. Week. December 6th 1988 Vol.4 No. 46. p.8.£

Gunn, S. (1989). New Heart for British Transplants. Horticulture Week. December 8th 1989. Vol.206, No. 21. pp.28-31.

Guttmann, A.J. (1977). Programming and Algorithms. Heinemann Educational Books Ltd, London. p.2.

Hall D.G.M, et al. (1977). Water retention, Porosity and Density of Field Soils. Technical Monograph No. 9. Soil Survey, Harpenden.

Hamilton G.J., Christie J.M. (1973). Construction and Application of Stand Yield Models Forestry Commission Research and Development Paper No. 96.

Hampshire, N. (1990). Whatever happened to...? Personal Computer World. Vol.13. No.4. pp.186-190.

Harris, R.W. (1983). Arboriculture: Care of Trees, Shrubs, and Vines in the Landscape. Prentice Hall, New York.

Hillier, H.G. (1981). Hillier's Manual of Trees and Shrubs. Van Nostrand Reinhold Company, London.

Hitchmough J.D. (1984a). The Development of a Computerised Retrieval System for Decorative Plant Selection. Ph.D Thesis, University of Bath.

Hitchmough J.D. (1984b). The Development of a Computerised Retrieval System for Decorative Plant Selection. Ph.D Thesis, University of Bath. pp. 74-107.

Hodgson, J.M. (1974). Soil Survey of England & Wales, "Soil Field Handbook". Technical Monogram No. 5.

Holmes J.C. (1984). Cultivations in Relation to Continuous Barley Growing. Reprint of Int. Conference of Tillage Methods, Silsoe, 1970 pp.47-57.

Hope F. (1981). Plant Selector II. A computerised Plant Selection Model. Gordian Computing Services.

Hope F. (1986a). The Development of a Computerised Information Retrieval System for Decorative Plant Selection. M.Phil. Thesis, University of Bath.

Hope F. (1986b). The Development of a Computerised Information Retrieval System for Decorative Plant Selection. M.Phil. Thesis, University of Bath. pp. 57-67.

Hope F. (1987). Genus Plant Selector II. Intersearch Systems Ltd. 3 Connaught Avenue, Frinton-On-Sea, Essex.

HMSO. (1982). Irrigation. ADAS Reference Book number 138. HMSO London.

HMSO. (1988). The Effects of the Great Storm. Report of a technical co-ordination committee and the governments response. HMSO, London.

Hudson, N. (1989). Soil Conservation. B.T. Batsford Ltd. London.

Hunt, D.R. (1978). The Living Collection Record File. Royal Botanic Gardens, Kew, London. Bull.33, pp.7-14.

Hunt R. (1982). Plant Growth Curves (1982). Edward & Arnold, London. England.

ICI (1986). Some things we can't control. Others we can. N-Sure topdressing service. N-Sure Newsletter 1986. Imperial Chemical Industries PLC. Farm advisory service. PO Box 1. Billingham, Cleveland. England.

ICRCL. (1983). Guidance on the assessment and redevelopment of contaminated land. ICRCL 59/83 DOE, London.

Insley, H. (1979). Damage to Broad-leaved Seedlings by Desiccation. DOE/Arboricultural Advisory and Information Service, Arboricultural Research Note 8/79/ARB.

Insley, H. (1982a). The Influence of Post Planting Maintenance on the Growth of Newly Planted Broad-leaved Trees. Cost Effective Amenity Landscape Management. HEA Conference proceedings 1982. p.74.

Insley, H. and Buckley, G. (1980) Some aspects of weed control for amenity trees on man made sites. Arboricultural Journal. 4 (2) pp.128-136.

Insley, H. & Patch, D. (1980). Root Deformation by Bio-degradable Containers. Forestry Commission Arboricultural Research Note. 22/80/ARB. HMSO, London.

Intersearch. (1989). Genus Plant Selector III. Intersearch Systems Ltd, Tendring, Essex.

Jackson, P. (1989). Bus Wars. Personal Computer World. March 1989, Vol.12. No.3. pp.140-143.

JCLI (1978). JCLI Plant List; Trees, Shrubs, Conifers. JCLI, Reading.

Jeffrey, D.W. (1987). Soil-Plant Relationships, an Ecological Approach. Croom Helm, London & Sydney 1987 pp.185-188.

Jobling, J. (1979). The Clones of Leyland Cypress. Forestry Commission Arboricultural Research Note 9/79/SILS.

Jones, R.G. (1980). The Long Term Benefits of Effective Weed Control in Young Forest Plantations. Advisory Note 8.1. Shell U.K. Ltd.

Jones, R.J.A. (1985). Median Accumulated Temperature Above 0°C (day-degrees). Soil Survey of England & Wales. Wolverhampton, England.

Kendle, T. (1988). The Optimisation of Tree Growth on China Clay Waste. Ph.D. thesis, Liverpool University, 1988.

Kendle, T. (1990). Personal comments.

Kernighan, B.W. & Ritchie, D.M. (1978). The C Programming Language. Prentice-Hall International, Inc. London.

Knuth, D.E. (1971-83). The Art of Computer Programming (First Edition). Volume III. Sorting and Searching. Addison-Wesley Publishing Company, London.

Landsberg, J.J. (1972-73). Micro-climate and the

Potential Productivity of Sites. Scientific Horticulture. 24, pp.126-140.

Lawes. (1978). Bioclimatic Maps of England and Wales. Soil Survey of England and Wales. Rothamsted, Harpenden, England.

Lawes. (1983). Legend for the 1:250,000 Soil Map of England and Wales. Rothamsted, Harpenden, England.

Lisney, C.C. (1983). Tree Establishment Symposium. University of Bath. 14/15 July 1983. pp.3-4.

Lodge, S. (1989). The Claris Crusade. MAC Magazine, October 1989.

Lotus Inc. (1982). Lotus 1-2-3 User Manual. Lotus Inc. USA.

Lotus Inc. (1983). Symphony User Manual. Lotus Inc, USA.

Macaulay, et al. (1988). Land Capability for Forestry in Britain. The Macaulay Land Use Institute Aberdeen, Scotland.

MAFF. (1954). The Calculation of Irrigation Need. Technical Bulletin no.4. HMSO, London.

MAFF. (1966). Agricultural Land Classification. Agricultural Land Service Report, Number 11.

MAFF. (1967). Atlas of Long Term Irrigation needs for England & Wales. MAFF, London.

MAFF. (1970). Modern Farming and Soil. HMSO. London.

MAFF. (1982). Irrigation. Reference Book 138. HMSO. London.

MAFF. (1983). Nutrition of Field Grown Nursery Stock. Leaflet number 642. HMSO, Alnwick, Northumberland NE66 2PF.

Manley, G. (1944). Topographical Features and the Climate of Britain. Geographical Journal. 103, (6) pp. 243-258.

McCavish, W.J. (1981). Grass Control Using "Herbon Lignum Granules". Forestry Commission Arboriculture Research Note 30/81/SILS. Forestry Commision, Alice Holt Lodge, Wrecclesham, Surrey.

McCavish W.J. & Insley, H. (1981). Herbicides for use with Broadleaved Amenity Trees. Forestry Commision Arboriculture Research Note 27/81/SILS. Forestry Commission, Alice Holt Lodge, Wrecclesham, Surrey.

McIntosh, R. (1984). Fertiliser Experiments in Established Conifer Stands. Forestry Commission Record Number 127. HMSO, London.

McGourty, F. (1982). Living With Clay. Plants and Gardens. Brooklyn Botanic Garden Record, Vol.38 No.1, pp. 50-51. Brooklyn, N.York.

McMennamy J.A. (1984). Dynamic Simulation of

Irrigated Rice Crop Growth and Yield. Int. Rice REs. Inst., Paper 79-07, December 1979.

Messem, A.B. (1975). A Rapid Method for the Determination of Potential Transpiration Derived from the Penman Combination Model. Agric. Meteorol. 14, pp.369-384.

Met Office. (1974). Maps of Mean and Extreme Temperatures over the United Kingdom. 1941-1970. Climatological memoirs 73. HMSO, London.

Meyer, L.D. (1979). Water Erosion, in: The Encyclopaedia of Soil Science Part 1. Ed. R.W. Fairbridge & C.W. Finkl Jnr, Dowden, Hutchinson, and Ross, Stroudburg, P.A.

Microsoft Corporation. (1979). Sirius I Reference Manual for BASIC-86. Part No. 100946-01. Sirius Systems Technology, Inc. Scotts Valley, CA 95066, USA.

Microsoft Corporation. (1987a). MS-Dos Operating System Vers. 3.3. for the Victor V286C. Victor Technologies Ltd, High Wycombe, Bucks.

Microsoft Corporation. (1987b). Microsoft Quickbasic 4.0 User manual. Redmond, WA 98073-9717.

Moen J.E.T., Cornet, J.P. & Evers, C.W.A. (1986). Soil protection and remedial actions. In contaminated Soil (Ed. J.W. Assinl & W.J. van den

Brink) pp.441-9. Martinus Nijhoff, dordrecht.

Morris, J.W. (1980). Encoding the National Herbarium Praetoria, South Africa, for Computerised Information Retrieval. Bothalia 13 (1-2), pp.149-160.

Morse, S.P. (1982). The 8086-8088 Primer (Second Edition). Hayden Book Company Inc, New Jersey, USA.

Mullin, R.E. (1971). Some Effects of Root Dipping, Root Exposure and Extended Planting Dates with White Spruce. Forestry Chronicle. 93. pp.1-4.

Mullin, R.E. (1974). Effects of root Exposure on the Establishment and Growth of Out-Planted Trees. In: Proceedings of the Second International Symposium on the Ecology and Physiology of Root Growth. 2. pp.229-244 Akademie Verlag. Berlin.

NEC (1988). Pinwriter P6 plus/P7 plus User's Guide. NEC (UK) Ltd, London.

NLIDB. (1989). North Level Internal Drainage Board Annual report. Thorney, Peterborough, Cambridgeshire.

Notcutt, C. (1983). Notcutt's Book of Plants (Enlarged Edition). Woodbridge, Suffolk.

Oke, T.R. (1978). Boundary layer climates. Methuen, London.

Older, C. (1983). Heavy Land Techniques at Home and

Abroad. Soil ans Water. Vol.11, No. 1. January 1983. pp. 26-27.

Oliver, J. (1960). Wind and Vegetation in the Dale Peninsula. Fld Stud. 1(2), pp.37-48.

Orson J.H. (1986). ICI N-Sure Newsletter September 1986. Reproduced from Farm Brief Publication July 30th 1986.

Patch, D. (1982). Tree Staking. Arboriculture Research Note 40/82/ARB. Forest Research Station, Alice Holt Lodge, Farnham, Surrey.

Patch, D., Binns, W.O., Fourt, D.F. (1984). Arboriculture research note number 52/84/SSS. Forestry Commission, Alice Holt Lodge, Farnham, Surrey.

PC Week. (1988a). The Future of the Disc. P.C. Week. December 6th 1988. Vol.4 No.6. pp.23-25.

PC Week. (1988b). Speaking in Many Tongues. PC Week, August 2nd, 1988, Vol.4 No.30. pp.17-19.

Penman, H.L. (1963). Irrigation in Great Britain. Journal of the Royal Society of Arts, pp.272-289.

Pepper, H.W. (1980). Plastic Net Tree Guards. Arboriculture Research Note 5/80/WILD. Forest Research Centre, Alice Holt Lodge, Farnham, Surrey.

Porter J.R. (1983). A Modular Approach to Analysis of Plant Growth. The New Phytologist. (1983) 94.

pp.183-190.

Porter J.R. (1985). Models and mechanisms in the growth and development of wheat. Outlook on Agriculture, Vol. 14. No. 4. 1985. Pergamon Press, London.

Porter J.R., Klepper B. and Belford R.K. (1986). A Model Which Synchronises Root Growth and Development with Shoot Development for Winter Wheat. Plant & Soil 92. pp.133-145 (1986).

Pountain, R. (1989). Powerpack. Personal Computer World. July 1989. Vol. 12, No. 7, pp.162-166.

Psion (1984). Quill User Manual. D. de Grandis-Harrison. Sinclair Research Ltd, Cambridge.

Purdum J.J. (1985a). Operators, Variables and Loops. C Programming Guide. 2nd. Edition. Que Corporation, Indianapolis. pp.33-38.

Purdum J.J. (1985b). Low Level File Input/Output. C Programming Guide. 2nd. Edition. Que Corporation, Indianapolis. pp.237-264.

Reed, T. (1989). Reed's Nautical Almanac. Thomas Reed Publications Ltd.

Rhehder, A. (1951). The Manual of Cultivated Trees and Shrubs Hardy in North America. Macmillan, New York, USA.

Robson, J.D. & Thomasson, A.J. (1977). Soil Water

Regimes. A Study of Seasonal Waterlogging in English Lowland Soils. Soil Survey. Tech. Monograph No. 11.

Rosen, S. (1969). Computing Surveys, Vol. 1, p.7.

Rosenfelder, L. (1981). BASIC Faster and Better. First edition, third printing. IJG, Inc. Upland, CA 91786, USA. p.9.

Robertson, A. (1987). The Use of Trees to Study Wind. Arboricultural Journal 1987. Vol.11, pp.127-143. AB Academic Publishers. Gt. Britain.

Sale P.J.M. (1984). The Response of Summer Lettuce to Irrigation at Different Stages of Growth. Reprint of J.Hort. Science. 41(1966).

Salter P.J. (1984). The Growth and Development of Early Summer Cauliflower in Relation to Environmental Factors. Reprint of J.Hort. Science. 35(1960).

Sawyer, T. (1989). Goodbye to the Drawing Board. Horticulture Week. Vol. 206, No. 4. July 28th, 1989. pp. 26-29.

Schildt, H. (1987). C the Complete Reference. Osborne McGraw-Hill. Pages 3 and 11.

Schildt, H. (1988). Advanced "C", Second edition. Osborne McGraw-Hill. Berkeley, California.

Shanks, C. (1985). Tree Shelters. Forest Research Station, Alice Holt Lodge, Farnham, surrey.

Shaw, R.L. (1978). How Ornamental Plants From Many Geographical Parts of the World have Responded to a Northern Climate. Scientific Horticulture. 30 (3) pp. 69-74.

Shepherd, M. (1986). ADAS-Advisor No. 57. January 1986. HMSO, London.

Simon, E.W., Dormer, K.J. & Hartshorne, J.N. (1983). Lowson's Botany, pp.611. Universal Tutorial Press Ltd. Slough, England.

Sinclair Research Ltd. (1985) QL. Gardener. Gordian Computing Services, Peterborough, Cat. No. 5515.

Skinner, D.N. (1986). Planting Success Rates - Standard trees. Arboricultural Research Note, Forestry Commission No. 66/86/EXT.

Smith, K. (1976). Climates of Coasts and Inland Water Bodies. In: The Climate of England and Wales. (Ed. T.J. Chandler & S. Gregory). Longman, London. pp.248-263.

Smith, L.P. (1976). The Agricultural Climate of England and Wales. Technical Bulletin no. 35. HMSO, London.

Smith, L.P. (1984). The Agricultural Climate of England and Wales. Reference Book no. 435. HMSO, London.

Spicer (1989). Late Developer. Personal Computer

World. November 1989. Vol.12. No.11. pp.182-186.

Steven M.D., Biscoe P.V., & Jaggard K.W. (1982). Estimation of Sugar Beet Productivity from Reflection in the Red and Infrared Spectral Bands. Int. Journal of Remote Sensing. 1983. Vol. 4, No. 2. pp.325-334.

Stephenson, A. (1981) - (Ed). The Garden Planner. William Collins & Sons, London.

Stoneham, J. & Thoday, P. (1985). Some Physiological Stresses Associated with Tree Transplanting. Scientific Horticulture 36. pp.83-91. 1985.

Sutcliffe, J. (1977). Plants and Temperature. Studies in Biology, No. 86. Edward Arnold, London.

Swaby, R.J. (1950). The Influence of Humus on Soil Aggregation. Journal of Soil Science. 1, pp.182-194.

Swarbrick, G. (1989). DataEase V.4.0. Personal Computer World. June 1989, Vol. 12 No. 6. pp.172-175.

Tabbush, P.M. (1986). Rough Handling Reduces the Viability of Planting Stock. Forestry Commission Arboriculture Research Note 64/86/SILN. HMSO, London.

Taylor, J.A. (1958). Growing Season as Affected by Aspect and Soil Texture. The Growing Season. Symposium held at the University College of Wales, Aberystwyth, 1-8.

Tanner, C.B. (1974). Micro-climatatic modifications: Basic concepts. Hort. Science. 9(6) pp.3-8.

Thoday, P.R. (1990). Life or Death for Tree Transplants. Horticulture Week, February 16, 1990. Vol. 207, No.7 p.24.

Thoday, P.R. & Kendle, T. (1990). A confidential report on the use of manufactured soils in the Landscape (Unpublished).

Thomas, D. (1958). Tree-crown Deformation as an Index of Exposure Intensity. Forestry, 31, pp.121-131.

Thornely, J.H.M. (1976). Mathematical Models in Plant Physiology : a Quantatative Approach to Problems in Plant and Crop Physiology. Academic Press, London.

Tisdale, S.L., Nelson, W.L. & Beaton, J.D. (1985). Soil Fertility and Fertilisers. Macmillan Publishers, England.

Troll, C. (1965). Seasonal Climates of the Earth. In: World Maps of Climatology (Ed. F. Rosenwaldt & H.J. Jusatz).

Tuley, G. (1983). Shelters Improve the Growth of Young Trees. Arboriculture Research Note 49/83/SILS. Forest Research Station, Alice Holt Lodge, Farnham, Surrey.

U.S.D.A. (1975). Soil Taxonomy. Agric. Handbook No. 436, U.S. Department of Agriculture.

Victor (1986). VBASICA. Victor Technologies Ltd. High Wycombe. England.

Victor (1987). Victor V286C Users Guide. Victor Technologies, Inc. High Wycombe, Bucks.

Vink A.P.A. (1983). Landscape Ecology and Land Use. pp.39-45.

Wadsworth, R.M. (1964). Wind Speed and Plant Growth. 2nd Symp. Shelter Res., Edinburgh, pp.13-25.

Walker, N. (1986). Macintosh Plus. Personal Computer World. February 1986. pp.120-123.

WPBS. (1988). Doubts on T°-Sums. Farming News, July 1, 1988. p.11.

Wheeler J.A., Audsley E. (1980). A Plant Growth Model to Study the Effects on Yield of Irrigation and Soil Compaction. NIAE. Department Note DN/OR/1026/11015.

Whitcomb, C.E. (1983). Why Large Trees are Difficult to Transplant. J. Arbor. 9(2), pp.57-59.

White, E.J. (1977). Computer Programs for the Estimation of Selected Climatic Variables and of Values of Principal Components Expressing Variation in Climate, for any Site in Great Britain. Institute of Terrestial Ecology, Merlewood Research and Development Paper No. 70, 1977.

White, E.J. (1980). Classification of Climate in Great Britain. Journal of Environmental Management (1981) 13, pp.241-257.

White E.J. & Lindley, D.K. (1976). The Reduction of Climatological Data for Ecological Purposes: A Preliminary Analysis. Journal of Environmental Management (1975) 4, pp.161-182.

Winter, E.J. (1978). Water Soil and the Plant. Science in Horticulture Series, Macmillan Press, London.

Worrel R. (1987). Predicting the Productivity of Sitka Spruce on Upland Sites in Northern Britain. Forestry Commission Bulletin No. 72. HMSO, London.

Wright, T.W.J. (1976). Micro-climate and plant selection. The garden, 101 (5), pp.234-241.

Zadoks (1983). 1983-4 Guide to Maximising Profits. BASF Ltd, Ipswich, England. pp.26-27.

Zorland (1986a). Zorland Graphics Toolkit. Zortech Ltd, London.

Zorland (1986b). Zorland "C" compiler vers. 2. User Manual, Zortech Ltd, London. pp.197-203.

Zortech (1988). Zortech C Compiler. Zortech Ltd.

APPENDIX A

PRE-RECORDED DATA STORED WITHIN THE PROGRAMME

PRE-RECORDED DATA STORED WITHIN THE PROGRAM

DSD = DORMANT SEASON IN DAYS

ALT = INITIAL ALTITUDE RATING IN METRES

EXP = INITIAL EXPOSURE RATING (1-4)

ICP = INITIAL COASTAL PROXIMITY RATING : 1 = INLAND

0°C = DAY DEGREES BELOW 0°C CORRECTED DATA

SMD = SOIL MOISTURE DEFICIT ZONAL RATING

EWR = EXCESS WINTER RAIN ZONAL RATING

CAP = RETURN TO FIELD CAPACITY ZONAL RATING

SOL = SOLAR RADIATION ZONAL RATING

ILL = ILLUMINATION ZONAL RATING

ZONE	DSD	ALT	EXP	ICP	0°C	SMD	EWR	CAP	SOL	ILL
1	128	67	2	1	40	1	2	1	116.0	1
2	127	66	2	1	45	1	2	1	113.9	1
3	165	214	3	1	105	1	2	1	111.6	1
4	128	109	2	1	65	1	1	1	118.0	1
5	176	315	3	1	135	1	1	1	117.1	1
6	123	97	2	1	60	1	2	1	115.8	1
7	175	341	3	1	130	1	1	1	112.5	1
8	135	172	3	1	60	1	2	1	119.8	1
9	127	116	2	1	50	1	1	1	121.4	1
10	107	28	2	1	45	1	1	1	124.6	1
11	156	287	3	1	105	1	1	1	117.7	1
12	133	138	2	1	80	1	1	1	117.6	1
13	120	39	2	1	55	1	2	1	121.6	1
14	118	54	2	1	45	1	2	1	119.4	1
15	109	65	2	1	50	1	1	2	120.3	1
16	136	169	2	1	85	1	2	2	119.8	1

ZONE	DSD	ALT	EXP	ICP	0°C	SMD	EWR	CAP	SOL	ILL
17	124	104	2	1	75	1	2	2	118.8	1
18	122	66	2	1	55	1	2	2	120.0	1
19	118	42	3	1	50	1	2	2	123.6	1
20	117	47	3	1	45	1	2	2	122.9	1
21	120	126	2	1	70	1	2	2	122.8	1
22	137	210	2	1	90	1	2	2	124.8	1
23	125	116	2	1	75	1	2	2	121.0	2
24	124	121	2	1	75	1	2	2	121.5	2
25	114	83	3	1	65	1	2	2	123.2	2
26	127	117	2	1	80	1	2	2	122.0	2
27	125	81	2	1	75	1	2	2	124.6	2
28	114	5	3	1	50	1	2	2	125.3	1
29	117	33	2	1	55	1	2	2	126.6	1
30	112	117	2	1	65	1	2	2	125.0	2
31	106	105	2	1	50	1	1	4	125.0	2
32	119	137	2	1	75	1	2	2	126.7	2
33	117	107	3	1	70	2	2	2	126.5	2
34	116	56	2	1	65	2	2	2	126.1	2
35	117	49	2	1	55	2	2	2	128.5	2
36	102	91	2	1	55	3	2	3	126.2	2
37	111	107	2	1	60	2	2	2	128.0	2
38	107	107	2	1	55	2	2	2	130.4	2
39	108	81	2	1	60	2	2	2	128.7	2
40	110	97	2	1	60	2	2	2	127.7	2
41	99	40	2	1	45	2	2	2	129.3	2
42	97	58	2	1	40	2	2	2	132.7	2
43	96	103	3	1	40	3	2	3	129.4	2
44	109	124	2	1	60	2	2	2	130.5	2

ZONE	DSD	ALT	EXP	ICP	0°C	SMD	EWR	CAP	SOL	ILL
45	107	64	2	1	55	2	2	2	131.8	2
46	97	64	2	1	40	2	2	2	131.8	2
47	107	79	2	1	45	2	2	2	132.4	2
48	97	70	3	1	40	2	2	2	138.3	2
49	109	80	2	1	45	2	2	2	132.0	2
50	96	49	3	1	40	2	2	2	135.3	2
51	43	83	3	1	5	3	3	3	132.1	2
52	71	127	3	1	20	3	3	3	130.0	2
53	72	81	3	1	10	3	3	3	132.3	2
54	108	236	3	1	35	3	3	3	127.7	2
55	81	129	3	1	10	3	3	3	131.8	2
56	98	208	3	1	30	3	3	3	130.7	2
57	94	110	3	1	30	3	3	3	133.7	2
58	90	102	3	1	30	3	2	3	132.9	2
59	86	45	2	1	30	3	2	2	135.4	2
60	88	61	3	1	10	1	1	4	123.1	1
61	140	299	4	1	80	1	1	4	119.3	1
62	140	282	3	1	75	1	1	4	123.4	2
63	142	345	3	1	80	1	1	4	121.5	1
64	136	309	3	1	85	1	1	4	123.4	1
65	94	123	3	1	25	1	1	4	127.4	2
66	136	297	3	1	75	1	1	4	127.2	2
67	97	103	3	1	35	1	1	4	126.8	2
68	103	146	3	1	10	1	1	1	112.5	2
69	0	18	3	1	0	3	3	3	132.1	2
70	33	56	3	1	10	2	2	2	142.0	1

APPENDIX B

GROWING—SEASON CLIMATIC DATA

GROWING - SEASON CLIMATIC DATA

(Data derived from Smith 1984)

Key to abbreviations

Z. = ZONE NUMBER

AIR = MEAN AIR TEMPERATURES IN °C

EARTH = MEAN EARTH TEMPERATURES IN °C

RAIN = MEAN RAINFALL IN MILLIMETRES

POT = MEAN POTENTIAL TRANSPIRATION IN MILLIMETRES

SUN = MEAN SUNLIGHT IN HRS/DAY

DAY = MEAN DAYLENGTH IN HOURS

RAD = MEAN SOLAR RADIATION IN MW-HRS PER CM^2

ILLUM = MEAN ILLUMINATION IN KILOLUX HOURS

Z.	AIR	EARTH	RAIN	POT	SUN	DAY	RAD	ILLUM
01	77.9	87.3	408.8	356.3	31.7	109.1	2188.8	2551.3
02	78.7	87.6	413.6	360.8	30.3	107.1	2118.7	2501.3
03	73.9	81.3	557.0	356.3	28.6	110.9	2174.5	2553.8
04	80.5	88.2	637.5	364.3	31.0	107.1	2178.2	2568.3
05	73.3	75.6	606.8	369.7	29.6	109.7	2241.7	2656.7
06	82.0	88.1	422.9	365.3	30.4	107.9	2146.7	2531.0
07	72.6	74.6	908.9	347.4	28.4	110.8	2209.3	2611.7
08	79.5	81.1	489.0	363.8	31.0	106.9	2202.3	2591.7
09	83.3	88.0	682.3	393.9	31.9	105.8	2212.3	2630.3
10	101.5	105.7	634.4	512.1	42.8	132.7	2814.4	3356.3
11	78.5	79.1	665.8	369.5	28.9	107.7	2188.3	2609.0
12	82.3	85.0	485.5	391.1	29.8	105.3	2154.0	2568.7
13	98.6	101.8	474.2	467.6	37.9	131.9	2656.5	3150.5
14	99.3	100.7	491.1	469.2	39.9	133.1	2724.7	3221.3
15	102.3	105.3	588.2	481.4	39.2	132.3	2704.5	3236.3
16	82.5	86.3	497.0	394.5	30.0	104.6	2174.2	2619.2

Z.	AIR	EARTH	RAIN	POT	SUN	DAY	RAD	ILLUM
17	99.0	100.6	518.7	478.6	37.5	131.1	2664.0	3193.9
18	100.3	102.7	463.0	495.5	39.1	132.0	2704.0	3239.9
19	101.1	102.0	453.6	501.7	42.1	131.8	2808.9	3348.5
20	99.7	101.1	485.2	489.9	42.1	132.4	2796.6	3340.8
21	96.7	103.0	557.7	481.7	40.1	130.9	2734.3	3287.6
22	81.3	87.0	501.7	400.6	32.1	104.8	2255.3	2722.3
23	98.0	106.0	517.5	488.5	39.0	132.3	2724.3	3277.3
24	98.7	106.1	509.1	482.5	39.0	130.7	2703.1	3262.7
25	100.7	108.8	484.4	489.1	40.3	129.1	2730.4	3323.3
26	98.5	104.6	481.9	482.1	39.9	130.4	2729.6	3304.6
27	100.4	104.7	464.1	497.2	41.5	131.1	2794.7	3365.8
28	102.4	104.8	433.3	511.8	44.1	131.4	2853.1	3434.5
29	102.4	105.3	459.3	513.7	44.3	131.2	2875.1	3453.1
30	100.6	106.8	553.5	483.8	41.1	130.5	2763.9	3354.0
31	101.7	109.7	682.3	485.3	41.6	129.9	2777.9	3394.2
32	100.3	107.1	533.7	487.8	41.9	130.4	2805.9	3409.1
33	102.0	106.7	493.3	495.0	42.3	130.4	2706.7	3423.9
34	103.2	108.5	431.9	506.7	43.0	131.0	2834.5	3432.3
35	103.8	109.2	447.5	518.5	44.6	130.7	2880.9	3493.1
36	104.3	108.8	576.0	486.8	41.9	129.6	2777.3	3404.0
37	103.2	107.1	496.4	496.7	42.9	129.6	2816.8	3454.5
38	102.7	107.7	575.3	491.3	42.9	129.8	2860.8	3522.1
39	103.9	110.3	524.6	503.5	43.6	130.4	2847.1	3490.8
40	104.3	106.9	494.1	504.2	43.4	130.9	2832.4	3477.4
41	106.7	112.4	440.7	513.9	44.7	130.5	2870.6	3506.5
42	108.4	112.6	479.8	516.5	46.7	130.1	2923.1	3582.7
43	102.9	110.7	631.8	494.1	44.0	129.5	2825.2	3491.1
44	101.8	104.7	581.2	492.7	44.0	129.9	2864.7	3508.1

Z.	AIR	EARTH	RAIN	POT	SUN	DAY	RAD	ILLUM
45	103.5	112.9	563.3	507.4	46.2	129.8	2194.4	3596.5
46	107.1	114.5	602.8	516.0	50.3	130.5	3039.2	3736.8
47	103.2	112.2	576.5	511.5	46.6	130.5	2933.5	3606.6
48	107.1	114.5	614.2	516.0	50.3	130.5	3039.2	3736.8
49	105.1	110.5	519.5	515.6	46.7	131.6	2947.1	3614.4
50	109.0	116.3	517.1	533.5	49.2	131.2	2996.1	3686.0
51	119.1	125.8	907.3	521.1	52.4	146.2	3167.2	3922.0
52	104.9	115.2	920.3	475.3	45.3	131.0	2846.9	3526.0
53	107.6	116.7	776.9	484.1	45.0	129.8	4845.2	3516.5
54	96.9	104.3	1003.8	452.8	40.8	131.4	2771.0	3436.5
55	103.4	114.2	832.0	471.0	43.8	131.0	2821.1	3470.6
56	99.7	109.2	904.7	453.1	43.1	131.8	2833.9	3476.9
57	103.5	113.6	673.1	499.1	46.0	129.2	2881.8	3573.9
58	103.5	113.4	645.4	484.3	45.4	128.6	2873.4	3555.2
59	108.2	117.3	599.7	508.1	48.4	129.4	2959.2	3650.6
60	100.6	108.4	752.4	482.5	45.3	132.7	2870.5	3434.0
61	77.1	82.1	1053.4	373.5	28.8	108.3	2175.5	2628.5
62	79.0	82.5	680.3	384.8	30.1	107.5	2210.8	2668.0
63	76.2	80.4	929.0	373.5	30.2	107.2	2227.5	2696.3
64	80.0	82.6	686.1	374.8	29.8	106.7	2204.3	2661.8
65	100.2	108.6	941.2	488.2	42.8	132.9	2811.8	3428.4
66	80.0	85.8	1061.5	381.7	31.9	104.5	2256.5	2766.0
67	104.4	110.7	858.1	487.0	42.5	131.1	2794.2	3420.6
68	95.1	0.0	1032.5	496.1	44.2	137.1	2861.3	3408.4
69	140.7	0.0	870.0	622.0	56.9	162.0	3375.0	4160.0
70	119.1	133.3	676.3	561.8	56.4	142.7	3247.8	4028.6

APPENDIX C

DORMANT-SEASON CLIMATIC DATA

DORMANT - SEASON CLIMATIC DATA

(Data derived from Smith 1984)

Key to abbreviations

Z. = ZONE NUMBER

AIR = MEAN AIR TEMPERATURES IN °C

EARTH = MEAN EARTH TEMPERATURES IN °C

RAIN = MEAN RAINFALL IN MILLIMETRES

POT = MEAN POTENTIAL TRANSPIRATION IN MILLIMETRES

SUN = MEAN SUNLIGHT IN HRS/DAY

DAY = MEAN DAYLENGTH IN HOURS

RAD = MEAN SOLAR RADIATION IN MW-HRS PER CM^2

ILLUM = MEAN ILLUMINATION IN KILOLUX HOURS

Z.	AIR	EARTH	RAIN	POT	SUN	DAY	RAD	ILLUM
01	21.6	21.2	242.2	86.7	13.4	56.2	721.2	818.7
02	22.5	22.1	256.4	90.2	13.7	57.7	741.3	858.7
03	14.4	18.3	382.0	43.7	9.5	54.1	515.5	601.2
04	21.9	22.2	407.5	79.7	13.3	57.2	731.8	851.7
05	13.0	16.8	461.2	32.3	9.5	54.6	503.3	583.3
06	21.9	21.2	246.1	89.7	12.9	56.4	718.3	839.0
07	12.7	16.2	754.1	26.6	8.2	53.4	470.7	543.3
08	21.1	20.3	319.0	73.2	12.3	57.1	692.7	808.3
09	22.7	22.8	450.7	90.1	13.0	57.9	747.7	864.7
10	12.4	12.8	202.6	25.9	6.1	30.9	275.6	308.7
11	16.9	19.1	485.2	45.5	9.4	55.8	576.7	666.0
12	21.7	21.8	321.5	82.9	11.9	58.2	696.0	821.3
13	11.3	12.1	168.8	18.4	5.5	32.0	243.5	269.5
14	11.1	11.1	163.9	14.8	5.2	30.6	230.3	253.7
15	11.9	13.1	197.8	20.6	5.9	31.0	270.5	298.7

Z.	AIR	EARTH	RAIN	POT	SUN	DAY	RAD	ILLUM
16	21.7	23.6	343.0	79.5	12.1	58.5	710.8	840.8
17	11.0	12.5	195.3	11.4	5.2	32.0	246.0	281.1
18	10.8	11.4	159.0	14.5	5.3	31.3	236.0	270.1
19	11.3	12.4	151.4	15.3	6.0	31.5	256.1	296.5
20	11.3	12.0	162.8	19.1	6.1	31.1	248.4	289.2
21	11.4	13.9	205.3	15.3	6.2	32.2	265.7	302.4
22	21.1	25.0	343.3	80.4	13.9	58.2	754.7	872.7
23	10.5	13.1	182.5	9.5	5.1	30.9	230.7	257.7
24	10.9	12.6	185.9	11.5	5.3	32.3	281.9	282.3
25	12.3	13.1	175.6	18.9	6.2	33.5	289.6	336.7
26	10.6	12.7	179.1	11.9	5.5	32.6	250.4	280.4
27	10.6	12.7	162.9	13.8	5.8	31.9	250.3	284.2
28	11.6	13.4	141.7	19.2	6.3	31.7	276.9	310.5
29	11.7	13.8	163.7	16.3	6.4	32.0	276.9	311.9
30	12.1	14.2	192.5	20.2	6.4	32.1	286.1	326.0
31	13.0	14.5	270.7	22.7	6.3	32.7	302.1	350.8
32	11.4	12.3	192.3	15.2	6.1	32.3	274.1	315.9
33	11.6	12.8	175.7	16.0	6.1	32.3	278.3	321.1
34	11.3	12.8	142.1	16.3	6.1	31.9	275.5	307.7
35	11.4	13.7	150.5	16.5	6.3	32.2	279.1	316.9
36	13.5	13.9	199.0	27.2	6.5	33.0	312.7	366.0
37	12.3	13.2	180.6	19.3	6.6	32.8	298.2	345.5
38	12.4	14.2	222.7	20.7	6.6	32.4	309.2	362.9
39	12.2	13.9	188.4	20.5	6.1	32.0	292.9	339.2
40	11.4	12.3	169.9	16.8	6.1	31.7	282.6	332.6
41	12.4	13.6	136.3	26.1	6.7	32.1	314.4	363.5
42	13.3	14.1	150.2	25.5	6.8	32.3	326.9	372.3
43	14.1	14.9	233.2	28.9	7.3	32.7	339.8	403.9

Z.	AIR	EARTH	RAIN	POT	SUN	DAY	RAD	ILLUM
44	12.4	13.6	217.8	18.3	6.9	32.2	305.3	366.9
45	12.4	14.4	214.7	23.6	6.9	32.4	310.6	368.5
46	13.3	14.2	217.2	30.0	7.3	31.5	330.8	383.2
47	11.9	13.4	214.5	19.5	6.3	31.7	296.5	348.4
48	13.3	14.3	221.8	30.0	7.3	31.5	330.8	383.2
49	11.4	13.2	176.5	16.4	6.1	30.8	282.9	325.6
50	13.1	14.4	165.9	29.5	6.9	31.2	318.9	374.0
51	8.6	8.5	135.2	12.9	3.4	15.3	147.8	173.0
52	15.4	16.0	320.7	38.7	7.6	31.0	378.1	439.0
53	16.2	17.3	271.1	42.9	7.9	32.1	389.8	453.5
54	12.2	15.2	445.2	14.2	5.5	30.6	274.0	323.5
55	14.7	16.1	301.0	33.0	7.3	31.0	348.9	414.4
56	12.9	15.6	360.3	19.9	6.2	30.4	301.1	353.1
57	14.8	16.5	236.9	35.9	8.1	32.8	373.2	401.1
58	14.6	16.8	239.6	29.7	8.1	33.4	371.6	434.8
59	14.7	16.2	207.3	34.9	8.2	32.6	370.8	439.4
60	15.0	15.0	251.6	33.5	7.5	30.6	334.5	376.0
61	19.3	21.0	775.6	62.5	10.6	54.8	639.5	746.5
62	19.5	21.7	503.7	65.2	12.0	55.6	674.2	792.0
63	19.1	21.9	703.0	60.5	11.4	55.7	667.5	783.7
64	19.6	23.2	503.9	68.2	11.9	56.2	695.7	818.2
65	13.3	14.3	316.8	24.8	6.4	29.8	298.2	346.6
66	21.1	24.7	560.5	74.3	13.0	58.1	738.5	879.0
67	13.3	14.4	313.9	23.0	6.7	31.5	315.8	364.4
68	11.9	0.0	315.5	32.9	5.6	26.9	228.7	261.6
69	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70	9.1	9.8	117.7	18.2	4.8	19.3	202.2	231.4

APPENDIX D

PRE-RECORDED SOIL AND SITE RELATED DATA

PRE-RECORDED SOIL AND SITE RELATED DATA

(Data derived from Soil Survey of England & Wales 1983)

Key to abbreviations

A = SOIL TEXTURAL GROUPING

B = SOIL DEPTH

C = DRAINAGE CHARACTERISTICS

D = GROUNDWATER CHARACTERISTICS

E = SLOPE

F = POSSIBILITY OF EROSION

G = SOIL STRUCTURE

H = PRESENCE OF SOIL PAN

I = SOIL pH RATING

J = ORGANIC MATTER CONTENT

K = CALCIUM CARBONATE CONTENT

L = SOIL NUTRIENT STATUS

M = ARTIFICIAL PROTECTION

N = WEED CONTROL

O = ARTIFICIAL IRRIGATION

The FILE NUMBER relates to the position in the SOL1.Dat data file, i.e. the file which is used to store the data for specific Soil Survey map subgroups.

FILE NO	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	4	1	1	3	1	2	2	1	2	1	2	1	1	1	1
2	5	2	2	3	2	2	2	1	3	2	1	1	1	1	1
3	5	2	2	3	2	2	2	2	3	2	1	1	1	1	1
4	1	2	1	1	2	2	1	1	1	1	2	1	1	1	1
5	1	2	1	1	1	1	1	1	1	1	2	1	1	1	1

FILE NO	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
6	5	2	2	3	2	2	2	1	3	2	1	1	1	1	1
7	1	2	1	1	2	2	1	1	1	2	1	1	1	1	1
8	1	2	1	1	2	2	1	1	1	2	1	2	1	1	1
9	1	2	1	1	2	2	1	1	1	2	2	2	1	1	1
10	5	2	1	1	2	2	1	1	2	2	2	2	1	1	1
11	3	2	1	1	2	2	1	1	2	2	2	2	1	1	1
12	3	2	1	1	1	1	1	1	2	2	2	2	1	1	1
13	3	2	1	1	1	1	1	1	2	1	2	2	1	1	1
14	3	2	1	1	1	1	1	1	2	2	2	2	1	1	1
15	1	2	1	1	1	1	1	1	2	2	2	2	1	1	1
16	1	2	1	1	1	1	1	1	2	2	2	2	1	1	1
17	1	2	1	1	1	1	1	1	2	2	2	2	1	1	1
18	2	2	1	1	1	1	1	1	2	2	2	2	1	1	1
19	1	2	1	1	1	1	1	1	2	2	2	2	1	1	1
20	4	2	1	1	1	2	1	1	2	2	2	2	1	1	1
21	1	2	1	1	1	2	1	1	2	2	2	2	1	1	1
22	3	2	1	1	2	2	1	1	2	2	2	2	1	1	1
23	3	2	1	1	1	1	1	1	2	2	2	2	1	1	1
24	5	2	2	1	1	1	1	1	2	2	2	3	1	1	1
25	4	1	1	1	1	2	1	1	1	1	2	1	1	1	1
26	3	1	2	1	1	2	1	1	2	2	2	3	1	1	1
27	2	2	2	1	1	1	1	1	2	2	2	2	1	1	1
28	2	1	2	3	1	1	1	1	2	1	2	2	1	1	1
29	2	1	2	1	1	1	1	1	2	2	2	2	1	1	1
30	2	1	2	1	1	2	1	1	2	2	2	2	1	1	1
31	2	1	2	1	2	2	1	1	1	2	1	2	1	1	1
32	2	1	2	1	1	1	1	1	1	2	1	2	1	1	1

FILE NO	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
33	2	1	2	1	1	2	2	1	1	2	1	2	1	1	1
34	1	2	1	1	1	1	2	1	2	2	2	2	1	1	1
35	2	1	1	1	1	1	1	1	2	2	2	2	1	1	1
36	3	1	1	1	1	1	1	1	2	2	2	2	1	1	1
37	2	1	1	1	1	1	1	1	2	2	2	2	1	1	1
38	1	1	1	1	1	2	1	1	2	2	2	2	1	1	1
39	3	2	1	1	2	2	1	1	2	2	2	1	1	1	1
40	3	1	1	1	1	1	1	1	2	2	2	2	1	1	1
41	1	1	1	1	1	1	1	1	2	2	2	2	1	1	1
42	1	1	1	1	1	1	1	1	2	2	2	2	1	1	1
43	2	1	1	1	1	1	1	1	2	2	2	2	1	1	1
44	1	2	1	1	1	1	1	1	2	2	2	2	1	1	1
45	1	1	1	3	1	1	1	1	2	2	2	2	1	1	1
46	1	1	1	3	1	1	1	1	2	2	2	2	1	1	1
47	1	1	2	3	1	1	1	1	2	2	2	2	1	1	1
48	1	1	2	3	1	1	1	1	2	2	2	2	1	1	1
49	1	1	1	3	1	1	1	1	2	2	2	2	1	1	1
50	1	1	2	3	1	1	1	1	2	2	2	2	1	1	1
51	4	1	1	1	1	2	2	1	2	1	2	1	1	1	1
52	3	1	1	1	1	1	1	1	2	2	2	3	1	1	1
53	3	1	1	1	1	1	1	1	2	2	2	3	1	1	1
54	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
55	1	2	1	1	1	2	1	1	1	2	1	2	1	1	1
56	1	2	1	1	1	1	1	1	1	2	1	2	1	1	1
57	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1
58	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1
59	1	1	1	1	1	1	1	1	1	2	1	2	1	1	1

FILE NO	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
60	1	1	1	1	1	1	1	1	1	2	1	2	1	1	1
61	1	1	1	1	1	1	1	1	1	2	1	2	1	1	1
62	3	1	1	1	1	2	1	1	1	2	1	2	1	1	1
63	1	1	1	1	1	1	1	1	1	2	1	2	1	1	1
64	1	1	1	1	1	1	1	1	1	2	1	2	1	1	1
65	3	1	1	1	1	2	1	1	1	2	1	2	1	1	1
66	3	1	1	1	1	1	1	1	1	2	1	3	1	1	1
67	1	1	1	1	1	1	1	1	1	2	1	2	1	1	1
68	3	1	1	1	1	1	2	1	1	2	2	1	1	1	1
69	3	1	1	1	1	1	1	1	1	2	2	2	1	1	1
70	1	1	1	1	1	1	1	1	1	2	1	2	1	1	1
71	1	1	1	1	1	2	1	1	1	2	1	3	1	1	1
72	1	1	1	1	1	2	1	1	1	2	1	3	1	1	1
73	1	1	1	1	1	2	1	1	1	2	1	3	1	1	1
74	1	1	1	1	1	1	1	1	1	2	1	2	1	1	1
75	1	2	1	1	1	1	1	1	1	2	1	2	1	1	1
76	1	1	1	1	1	1	1	1	1	2	1	2	1	1	1
77	1	1	1	1	1	1	1	1	1	2	1	2	1	1	1
78	1	1	1	1	1	1	1	1	1	2	1	2	1	1	1
79	1	1	1	1	1	1	1	1	1	2	1	2	1	1	1
80	1	1	1	1	1	2	1	1	1	2	1	2	1	1	1
81	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1
82	1	1	1	1	1	1	1	1	1	2	1	2	1	1	1
83	1	1	1	1	1	1	1	1	1	2	1	2	1	1	1
84	1	1	2	3	1	1	1	1	1	2	1	2	1	1	1
85	1	1	1	3	1	1	1	1	1	2	1	2	1	1	1
86	1	1	1	1	1	1	1	1	1	2	1	2	1	1	1

FILE NO	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
87	4	1	1	1	1	2	1	1	1	1	1	2	1	1	1
88	4	1	1	1	1	2	1	1	1	1	1	2	1	1	1
89	4	1	1	1	1	2	1	1	1	1	1	2	1	1	1
90	4	1	1	1	1	2	1	1	1	1	1	2	1	1	1
91	4	1	1	1	1	2	1	1	1	2	1	2	1	1	1
92	4	1	1	1	1	2	1	1	1	1	1	2	1	1	1
93	4	1	1	1	1	2	1	1	1	1	1	2	1	1	1
94	4	1	1	3	1	2	1	1	1	1	1	2	1	1	1
95	4	1	1	3	1	1	1	1	1	1	1	2	1	1	1
96	4	1	1	1	1	2	1	1	1	1	1	2	1	1	1
97	4	1	1	1	1	2	1	1	3	2	1	1	1	1	1
98	4	1	1	1	1	1	1	1	1	2	1	2	1	1	1
99	1	1	1	3	1	1	1	1	1	1	1	2	1	1	1
100	3	1	1	3	1	1	1	1	1	1	1	2	1	1	1
101	1	1	1	3	1	1	1	1	1	1	1	2	1	1	1
102	3	1	1	3	1	1	1	1	1	2	1	2	1	1	1
103	3	1	1	1	1	1	1	1	1	2	1	2	1	1	1
104	3	1	1	1	1	2	1	1	1	2	1	2	1	1	1
105	1	1	1	1	1	1	1	1	1	2	1	2	1	1	1
106	1	1	1	1	1	2	1	1	1	2	1	2	1	1	1
107	1	1	2	1	1	2	1	1	3	2	1	1	1	1	1
108	1	1	1	1	1	1	1	1	3	2	1	1	1	1	1
109	1	1	1	1	1	2	1	1	1	2	1	2	1	1	1
110	1	1	1	1	1	1	1	1	1	2	1	2	1	1	1
111	1	1	1	1	1	2	1	1	1	2	1	2	1	1	1
112	1	1	1	1	1	1	1	1	2	2	2	2	1	1	1
113	1	1	1	1	1	2	1	1	2	2	2	2	1	1	1

FILE NO	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
114	3	1	1	1	1	1	1	1	1	2	1	2	1	1	1
115	3	1	1	1	1	1	1	1	1	1	2	1	1	1	1
116	1	1	1	1	1	1	1	1	2	2	2	2	1	1	1
117	1	1	1	1	1	1	1	1	2	1	2	2	1	1	1
118	1	1	1	1	1	1	1	1	1	2	1	2	1	1	1
119	1	1	1	1	1	1	1	1	1	2	1	2	1	1	1
120	1	1	1	1	1	1	1	1	2	2	2	2	1	1	1
121	1	1	1	1	1	1	1	1	1	2	1	3	1	1	1
122	1	1	1	1	1	1	1	1	1	2	1	2	1	1	1
123	1	1	1	1	1	1	1	1	1	2	1	2	1	1	1
124	1	1	1	1	1	1	1	1	1	1	2	2	1	1	1
125	1	1	1	1	1	1	1	1	1	2	1	3	1	1	1
126	1	1	1	1	1	2	1	1	1	2	1	3	1	1	1
127	3	1	1	1	1	2	1	1	1	2	1	3	1	1	1
128	3	1	1	1	1	1	1	1	1	2	1	3	1	1	1
129	3	1	1	1	1	1	1	1	1	1	1	2	1	1	1
130	3	1	2	3	1	1	1	1	1	1	1	1	1	1	1
131	3	1	2	3	1	1	1	1	1	1	1	1	1	1	1
132	1	1	2	3	1	2	1	1	1	2	1	2	1	1	1
133	1	1	2	3	1	1	1	1	1	2	1	2	1	1	1
134	1	1	2	3	1	1	1	1	1	2	1	2	1	1	1
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APPENDIX E

NOTES AND RECOMMENDATIONS

Notes and Recommendations

General note relating to altitude

As altitude increases climatic changes occur which can adversely affect the growth and establishment of plants. The most important of these changes are a lowering of air and earth temperatures, higher rainfall, a shortening of the growing season and a potential increase in the frequency and severity of ground and air frosts. Taxa which are not Frost Hardy may be severely damaged, or even killed at relatively low altitudes, especially when grown in exposed situations, or in 'frost pockets', where the movement of cold air is restricted by either a natural or man made barrier.

Altitude above 375 metres but less than 670 metres

The altitude of the site will restrict establishment and growth.

Altitude plus exposure

The altitude and exposure of the site will severely restrict establishment and growth.

Altitude plus severe exposure

The altitude and severe exposure of the site will prevent the establishment and growth of most taxa.

Altitude plus shelter

The altitude of the site may restrict establishment and growth.

Altitude above 670 metres

The extreme altitude of the site will prevent the establishment of all but the hardiest of taxa.

Coastal with shelter

Coastal regions of England and Wales experience a slightly different climate to more inland sites. For example, most of the British coastline shows a significant reduction in the intensity of winter cold. In sheltered coastal sites it is sometimes possible to establish and grow a wide range of non hardy taxa. This is possible because shelter helps to diminish the buffeting effects of strong sea breezes whilst significantly reducing the degree of scorch caused by salt deposits on plant leaves.

Coastal without shelter

In general, coastal regions of England and Wales exhibit a more equable climate than inland areas, i.e. daily maximum temperatures are lower whilst nightly minimum temperatures are higher. Sunshine and radiation are strongest in coastal localities which lead to high values of potential transpiration. In exposed situations strong salt laden sea breezes can reduce the establishment and growth of young plants, whereas established taxa can exhibit considerable malformed growth. However, sheltered coastal locations can allow the establishment of a large range of non-hardy taxa.

Exposed sites less than 375 metres high

In exposed situations plant establishment and growth may be adversely affected. The major causes of damage are excessive transpiration and physical buffeting, both of which become more pronounced with increasing air speeds and altitude. In these situations some form of shelter, either natural or artificial will often aid establishment.

Exposed sites greater than 375 metres high

In exposed situations at high altitude plant establishment and growth can be seriously affected. The combination of low air/earth temperatures, increase of transpiration, shortened growing season and the effects of physical buffeting can cause desiccation, wind rock, or unsightly wind pruned and unidirectional growth. Even if no visible sign of damage is produced plant vigour will usually be severely checked. On exposed sites at altitude very few taxa will be adaptable enough to be able to survive. Those which can will usually be low growing or have specialised features to enable them to conserve moisture by reducing their rate of transpiration.

Exposed coastal sites

In exposed coastal situations plant establishment can be seriously affected by high wind speeds which carry a high percentage of salt. Strong sea breezes may cause severe buffeting, desiccation & physical damage to plant tissue, whilst salt laden winds can cause scorching. Given some form of shelter, many taxa will establish and grow successfully in areas of coastal exposure, however, some tissue scorching and reduced growth will almost certainly occur when shelter is inadequate.

Very exposed sites

In situations of very high exposure the majority of plants will be unable to survive, or if they do the growth produced will be stunted, wind pruned and unidirectional. The plants which can exist will be low growing, or have specialised modifications to reduce excessive amounts of transpiration. Artificial shelter of some form may alleviate the problem.

Loamy soils

Loamy soils consist of a mixture of sand, silt, clay and organic matter. They are well structured, have a high cation exchange capacity, and the potential for maximising plant growth.

When stripped, stored and respread, loams may lose their crumb structure., and their organic matter content may undergo anaerobic breakdown. Always cultivate thoroughly after respreading.

Loamy topsoils often rest upon heavier, organic matter deficient sub-soils which compact easily producing impeded drainage. If through topsoil loss these become the root zone do not work when wet and always cultivate deeply incorporating some form of organic matter to improve structure.

Clayey soils

Clay soils have tiny air spaces which are capable of retaining a relatively large amount of moisture. They have a high cation exchange capacity, but are prone to structure instability. The correct management of these soils is critical. Damage will occur if they are worked when wet, or if their bulk density is increased by compaction.

Clay soils when stripped stored and respread do remain fertile but are prone to poor structure. Do not work when wet. Cultivate deeply and incorporate organic matter. Do not rotovate.

Exposed clay subsoils have an inherent weak structure, lack organic matter and are prone to bad drainage and compaction. Do not work when wet. Cultivate deeply, but do not rotovate.

Silty soils

Silt particle size is intermediate between sand and clay. In general silts exhibit poor colloidal properties, but have the ability to retain soil water. Unfortunately, they can be prone to soil instability due to the lack of clay and organic colloids. They also have a tendency to surface capping during dry or windy conditions. With the incorporation of bulky organic matter and correct management these soils can provide a good substrate

for plant establishment and growth.
Silty soils when stripped, stored and respread do become structureless and prone to waterlogging.
Exposed silt subsoils tend to be raw silts with little if any organic matter. They are poorly structured and in many cases, badly drained.

Sandy soils

Sandy soils are formed mainly from quartz or silica and are resistant to weathering. Most contain large air spaces and have poor moisture and nutrient retaining capacity. They are well drained and aerated, and easily cultivated. They can dry out quickly in dry periods, but soil management is usually simpler than other soil types, as their structure is only rarely adversely affected by inclement weather.
Sandy soils generally rest upon sandy subsoils. When stripped, stored and respread the physical and chemical state of sands changes little.
Exposed sandy subsoils typically have exceptionally sharp drainage and are deficient in nutrients and organic matter.

Organic soils

Organic soils are capable of retaining large quantities of soil moisture. In general, they are found on flat land and are very acid. When drained they produce high quality soils, and they can be worked during inclement weather without damaging the soil structure. True organic soils, 'blow' in exposed situations, they provide a poor anchorage for roots, and contain a very high number of weed seeds which are difficult to control with residual herbicides.

When stripped, stored and respread their physical state changes little from those left in situ.

The removal of peat soil can reveal either raw peat or very contrasting materials ranging from sand to clay. This change of substrate is exploited by some landscapers. Removal of peaty topsoil may result in a very high water table.

<u>Industrial and demolition site type substrates</u>

Industrial or demolition substrates appear hostile but their physical structure is often supportive of good plant growth. However, they are often prone to drought, lack fine particles and organic matter.

Plant nutrient availability varies widely. Building rubble often has sufficient potassium, phosphorus and most micro-nutrients. All such soils are likely to be extremely deficient in nitrogen.

Chemical toxicity can be a major problem on industrial spoils and contaminated land. The DOE trigger concentrations should be referred to, as these will highlight possible problems, and give guidance on permissible after uses.

<u>Shallow soils</u>

Shallow soil with an impervious subsoil may be found naturally on sloping land following erosion, on development sites where the topsoil is removed and only partially returned, on sites where an artificial sub-surface barrier i.e. a pan, is present, or on sites where the subsoil is found naturally within 100mm of the soil surface. Depending upon the type of sub-soil, shallowness can lead to inadequate rooting depth and poor moisture holding capacity, both of which can lead to severe stunting of growth and, in exposed conditions, plants will be liable to wind-blow. On sites where shallow soils have pervious sub-soils rooting depth may be great enough to provide adequate moisture and stability.

Slowly permeable or clay soils

Soil permeability is the term used to describe the speed at which water is drained from soil after rain. Clays and soils which have inherently weak, or artificially damaged structures usually exhibit slow permeability. In these soils, moisture levels after rain stay high whilst oxygen content is often well below optimum. One of the major problems with these soils is the timing of management operations. If work is carried out when they are too wet it is extremely easy to ruin the soil structure and consequently reduce establishment and growth.

Waterlogged soils

When soils become water-logged all of the air spaces between the soil particles become filled with water and the air is forced out. This produces anaerobic conditions which typically kill transplant roots. If this state persists a marked loss of soil structure will result and considerable nutrient loss through leaching may occur. Water-logged soils are extremely difficult to manage and totally useless for growing ornamental taxa. Before any planting is considered these soils should be drained to outfalls and the soil structure improved.

<u>Seasonally waterlogged soils</u>

Gleys, which exhibit distinct sub-surface colouring are the classic soils that suffer from periodic waterlogging. Usually these soils have either an impermeable layer within the soil which causes the upper layers to become water-logged, or there is a ground-water table that comes close to the surface. Few plants can flourish in these conditions, but the range of taxa can be increased by carrying out drainage. It is important to note that the structure of these soils is often inherently weak, which means that correct soil management and the timing of planting is critical.

<u>Steeply sloping sites</u>

Planting sites on steep slopes exhibit a number of physical and management problems. They can have a distinct range of soil depth; shallow close to the summit, and deep at their base. Anchorage of roots and soil stability must be taken into account when selecting taxa; it may be necessary to provide some form of artificial barrier to prevent land movement or erosion. Soil moisture and nutrients can be easily leached from sloping land; it may be prudent to apply nutrients and water artificially to ensure adequate quantities are always available.

<u>Soil erosion</u>

The two major causes of soil erosion are wind and rain. Wind erosion usually takes place in exposed situations and involves soils which are open and lacking binding agents. The typical soil types that are affected in this way are bare sands and drained uncovered Fenland type peats. Wind erosion can be minimised by the use of soil stabilisers and the planting of guard, or cover crops. Erosion caused by water usually occurs on sloping land or close to waterways where the downward movement of water physically carries soil and nutrients away.

<u>Poorly structured soils</u>

Structure is the term used to describe the way soil particles are arranged together. Good structure leads to well-drained & well-aerated soil, whereas poor structure can lead to waterlogging & anaerobic conditions. It is essential that good structure is maintained. This can be aided by never working the soil when it is wet, and by the incorporation of bulky organic materials. Planting on soils with a damaged or inherently weak structure can lead to a marked reduction in plant establishment and growth.

Presence of soil pans

Two types of soil pan are occasionally found in the British Isles. The first is produced by a downward movement of soil chemicals & is typical of Podzols. The second is more subtle in that it is formed via incorrect management, e.g. creating a smeared surface beneath soil level. This is usually found after cultivating at a constant depth over a period of time, although it is possible on clayey soils to produce a smeared face after only one cultivation. It is essential that pans should be broken up before planting is carried out, otherwise poor drainage/aeration and shallow rooting will lead to poor establishment and growth. It is possible to increase localised soil bulk density at depth by running heavy machinery over the soil. Where this occurs soil pans can actually be created during the planting site preparation.

Slightly acid soils

The pH scale ranges from 0-14. Soils with a pH of 7 are classed as neutral; readings below 7 indicate acidity, and readings above 7 indicate alkalinity. The majority of plants can grow successfully in abroad range of pH, it is only in extremes, i.e. very acid or very alkaline conditions, that problems may arise for such plants. Note that a small number of taxa are tolerant of either, or both extremes, but that these usually have a specialised morphological structure which enables them to survive in extreme conditions.

<u>soils with a high pH</u>

The pH scale ranges from 0-14. Soils with a pH of 7 are classed as neutral; readings below 7 indicate acidity, and readings above 7 indicate alkalinity. Only a few ornamental taxa thrive on soils with an extremely high pH.

<u>Soils with a low pH</u>

The pH scale ranges from 0-14. Soils with a pH of 7 are classed as neutral; readings below 7 indicate acidity, and readings above 7 indicate alkalinity. Only a few ornamental taxa thrive on soils with an extremely low pH.

<u>Low organic matter soils</u>

Organic matter aids the retention of soil moisture, provides nutrients for growth, acts as a nutrient buffer & above all helps to improve soil structure with a subsequent improvement in workability and root spread. In denatured soils where structure is extremely poor organic matter incorporated into the surface layers can physically open up the soil and allow moisture and oxygen to enter.

<u>Calcareous and shallow soils</u>

Shallow calcareous soils have a naturally high pH, low nutrient holding capacity, a tendency to become sticky when wet, but can crack when dry. Plants grown on these soils usually have unnaturally shallow root systems which can lead to wind-blow in exposed situations. These soils tend to dry out quickly in fine weather which can encourage poor, stunted and often chlorotic growth. Shallow calcareous soils have an inherently poor structure which is easily damaged if worked when wet.

Calcareous soils

These soils are developed from calcareous parent materials, contain primary calcium carbonate in the soil horizons and are base saturated. They have a naturally high pH, low nutrient holding capacity, a tendency to become sticky when wet, but can crack when dry. A large number of plants are capable of establishing and growing on calcareous soils, but those taxa which are intolerant exhibit stunted, chlorotic growth which eventually leads to death. The structure of calcareous soils can be easily damaged, to prevent this from happening planting preparation should not be carried out when the soil is wet or sticky.

Low nutrient status soils

Few ornamental plants, when grown on sites with a low nutrient status, will achieve their maximum potential, whereas taxa grown on severely nutrient deficient soils may become stunted, chlorotic or even die. Before plants can grow successfully they require a number of major and micro nutrients. On problem sites it is recommended that a full soil analysis be carried out to identify specific nutrient problems. Fertiliser recommendations can then be formulated to meet the demands of the site and taxa. Fortunately, most soils will contain adequate amounts of micro nutrients and only applications of the major ones i.e. nitrogen, phosphorus, potassium and possibly magnesium will be necessary.

Soil index of 0

Nitrogen Applications (Index 0)

Ist Year	kg/ha N
Slow growing species	50
Faster growing species	100
2nd & Subsequent Years	**kg/ha N**
Slow growing species	0- 50
Faster growing species	50-150

Newly planted stock is sensitive to excessive rates of soluble fertiliser. For all species do not apply more than 50kg/ha of nitrogen before planting, the remainder being applied as a top-dressing once the plants are established.

Soil index of 1

Nitrogen Applications (Index 1)

Ist Year	kg/ha N
Slow growing species	25

Faster growing species	50

2nd & Subsequent Years

	Kg/ha N
Slow growing species	0- 50
Faster growing species	50-150

Newly planted stock is sensitive to excessive rates of soluble fertiliser. For all species do not apply more than 50kg/ha of nitrogen before planting, the remainder being applied as a top-dressing once the plants are established.

Phosphate, potash & magnesium Application (Index 0)

Ist Year

Before planting	kg/ha
Phosphate (P205)	100
Potash (K2O)	200
Magnesium (Mg)	75

Topdressing in 2nd & subsequent years

	kg/ha
Phosphate (P205)	50
Potash (K2O)	100
Magnesium (Mg)	25

Magnesium content may be quoted in terms of the oxide (MgO) to convert from Mg to MgO the figures in the table should be multiplied by 1.7

Phosphate, potash & magnesium Application (Index 1)

Ist Year

Before planting	kg/ha
Phosphate (P205)	75
Potash (K2O)	150
Magnesium (Mg)	50

Topdressing in 2nd & subsequent years

	kg/ha
Phosphate (P2O5)	25
Potash (K2O)	50
Magnesium (Mg)	0

Magnesium content may be quoted in terms of the oxide (MgO) to convert from Mg to MgO the figures in the table should be multiplied by 1.7

Phosphate, potash & magnesium Application (Index 2)

Ist Year

Before planting	kg/ha
Phosphate (P2O5)	50
Potash (K2O)	100
Magnesium (Mg)	25

Topdressing in 2nd & subsequent years

	kg/ha
Phosphate (P2O5)	0
Potash (K2O)	25
Magnesium (Mg)	0

Magnesium content may be quoted in terms of the oxide (MgO) to convert from Mg to MgO the figures in the table should be multiplied by 1.7

Phosphate, potash & magnesium Application (Index 3)

Ist Year

Before planting	kg/ha
Phosphate (P2O5)	25
Potash (K2O)	50
Magnesium (Mg)	0

Topdressing in 2nd & subsequent years

	kg/ha
Phosphate (P2O5)	0
Potash (K2O)	0
Magnesium (Mg)	0

Magnesium content may be quoted in terms of the oxide (MgO) to convert from Mg to MgO the figures in the table should be multiplied by 1.7

Organic matter applied

As the bulky organic matter content of the site is high the pre-planting fertiliser applications can be reduced by 20kg of P_2O_5, 40kg K_2O and 8kg of Mg per 10 tonnes of manure, but a minimum of 50kg/ha P_2O_5 and K_2O as fertiliser should always be applied when the soil index is 0 or 1.

Sheltered sites with no protection

Recent experiments have shown that the use of tree-shelters can produce a favourable micro-climate around a plant by acting as individual greenhouses. Some species have more than doubled in height when compared to unsheltered plants. The most dramatic growth increase is usually found in the second year after planting. Growth slows down once the plants emerge from the protection.

Exposed sites with no protection

Recent experiments have shown that the use of tree-shelters can produce a favourable micro-climate around a plant by acting as individual greenhouses. Some initial benefit may be obtained from the use of these shelters, although growth can be severely checked once the plant emerges from the shelter. It has been shown that when tree shelters are used in exposed situations the survival rate and growth of coniferous and certain deciduous taxa is increased.

<u>Coastal sites with no protection</u>

Recent experiments have shown that the use of tree-shelters can produce a favourable micro-climate around a plant by acting as individual greenhouses. Some initial benefit may be obtained from the use of these shelters as they provide a barrier from strong sea breezes, and reduce the amount of salt being deposited on the plant leaves. It must be recognised, however, that growth can be severely checked once the plant emerges from the shelter.

<u>No weed control and no artificial irrigation</u>

Research has shown that the elimination of competing vegetation at the base of newly planted trees and shrubs is beneficial to their establishment and early growth. Weeds compete for moisture, light and nutrients; grass and clover species being extremely competitive. The use of herbicides, or mulches for the first 2 or 3 years after planting can give substantial percentage increases in both establishment and growth. Total weed control throughout the growing season for a minimum of 1 metre diameter from the base of plants is ideal, although even one or two applications of herbicide during spring and early summer, giving less than 1 metre, is highly beneficial.

No weed control until mid-late June

Weeds actively compete for soil moisture, light and nutrients. Competition is usually most detrimental in April, May and June. Soil moisture deficits usually start during this period and transpiration from competing weeds result in larger deficits for the whole growing season. Thus one weeks weed growth in April may reduce soil moisture availability from April through to October. Given a weed free site in spring transplants produce early root growth which allows them to withstand some weed re-invasion although they grow better if kept weed free throughout the growing season.

No weed control until mid-late July

Competition from weeds is usually most detrimental in April, May and June of the first year after planting. Effective weed control can be achieved by applying herbicides or mulches early in the season to remove competition before the trees and shrubs come into growth. Given a weed free start trees and shrubs make early root growth and withstand some re-invasion later in the season. Weed control until the mid to end of July will alleviate most of the competition although total weed control through-out the season allows for maximum growth.

No artificial irrigation in high rainfall locations

In areas of high rainfall where the soil is deep and the site is level there is no need for regular irrigation, however, it is usually prudent to water taxa in at planting time. For more detail consult the Mean Rainfall data for the months of April to June.

<u>No artificial irrigation in high rainfall areas with shallow, steep or exposed sites</u>

In areas of high rainfall there is no need to carry out regular irrigation of newly planted taxa, but it is normally advantageous to water the plants in at planting time. All parts of the British Isles are occasionally subject to periods of drought. When these occur, or when the soil is shallow, or exposed it is recommended that 25mm of water should be applied when a 50mm soil moisture deficit exists.

<u>No artificial irrigation in high rainfall locations with shallow soils, pans, organic matter added, or steeply sloping</u>

In areas of high rainfall there is usually no need to carry out regular irrigation of newly planted taxa. However, it is normally advantageous to water the plants in at planting time. When the soil is shallow, or the site is on a steep slope or exposed moisture deficits may occur, although where farmyard manure has been applied deficits should be rare. If they do occur it is recommended that 25mm of water should be applied to the soil when a 50mm deficit is reached.

Artificial irrigation applied to water-logged or seasonally water-logged sites

Few ornamental woody plants can grow in seasonally or totally water-logged soil. The addition of water to these sites would only make soil conditions worse, and so no recommendation for irrigation is given.

Artificial irrigation applied to soils with poor structure

The application of irrigation water to soils with inherently poor, or damaged structure can lead to water-logging and anaerobic conditions. In these situations water should be applied very carefully so as to ensure that surface puddling or capping does not take place, i.e. the application rate must be less than the infiltration rate of the soil.

Artificial irrigation given to loamy, clayey, or sandy soils in low or average rainfall zones

The soil should be as close to field capacity as practical before soil preparation takes place, or the taxa should be watered in immediately after planting. If soil moisture deficits occur in April to June newly planted stock should be given 25mm of water when a 50mm deficit exists. With established taxa the critical period for water is between May and July; when a 50mm deficit occurs 25mm of water should be applied. Whenever irrigation is used it is important to ensure that the application rate is less than the soil infiltration rate, otherwise puddles may be created and soil structure damaged.

Artificial irrigation given to peaty or sandy soils in low to average rainfall zones

The soil should be as close to field capacity as practical before soil preparation takes place, or the taxa should be watered in immediately after planting. If soil moisture deficits occur in April to June newly planted stock should be given 25mm of water when a 50mm+ deficit exists. With established taxa the critical period for water is between May and July; when a 50mm+ deficit occurs 25mm of water should be applied. Whenever irrigation is used it is important to ensure that the application rate is less than the soil infiltration rate, otherwise puddles may be created and soil structure damaged. If water is applied too quickly to a sloping site 'run off' will occur which could, in turn, lead to gulley erosion.

APPENDIX F

EXPERIMENTAL DATA

Abies procera weed control experiment data

BL = Block

TN = Tree number

IW = Initial weight in grammes

FW = Final weight in grammes

IH = Initial height in millimetres

FH = Final height in millimetres

* = Dead plant

Treatment 1 – Total weed control

Treatment 2 – Weeds controlled on the 29th June

Treatment 3 – Weeds controlled on the 27th July

Treatment 4 – Weeds present continuously

Treatment	BL	TN	IW	FW	IH	FH
1	1	1	23.1	61.6	141	211
1	1	2	21.3	54.8	140	180
1	1	3	21.1	51.1	120	184
1	1	4	17.2	46.9	111	165
1	1	5	18.2	58.2	130	191
1	1	6	17.1	62.5	110	162
1	1	7	19.3	48.1	115	150
1	1	8	16.4	52.3	115	176
1	1	9	23.3	71.4	120	180
1	1	10	16.5	31.9	122	192
1	1	11	22.1	54.6	110	170
1	1	12	19.2	68.5	100	190
1	2	1	19.3	70.6	125	190
1	2	2	16.1	78.2	131	196
1	2	3	22.4	50.1	130	185

Treatment	BL	TN	IW	FW	IH	FH
1	2	4	16.1	62.3	130	179
1	2	5	24.1	53.1	126	160
1	2	6	17.2	45.9	115	179
1	2	7	18.3	44.2	97	146
1	2	8	22.2	89.9	124	182
1	2	9	22.1	86.0	140	198
1	2	10	23.2	46.3	121	160
1	2	11	23.3	57.7	119	180
1	2	12	23.2	85.6	135	224
1	3	1	23.1	42.2	121	130
1	3	2	24.1	48.6	136	160
1	3	3	19.2	54.0	130	194
1	3	4	18.1	42.5	111	170
1	3	5	17.3	83.3	110	223
1	3	6	16.5	52.4	109	222
1	3	7	16.3	78.0	120	177
1	3	8	17.2	84.4	110	210
1	3	9	23.1	*	115	*
1	3	10	21.2	49.5	134	211
1	3	11	24.3	70.2	131	185
1	3	12	20.6	62.7	121	227
1	4	1	23.2	55.0	130	193
1	4	2	24.1	41.5	135	194
1	4	3	16.2	85.2	141	230
1	4	4	17.1	78.0	105	184
1	4	5	16.3	66.3	139	205
1	4	6	19.1	86.7	105	199
1	4	7	19.3	55.1	134	176

Treatment	BL	TN	IW	FW	IH	FH
1	4	8	17.2	46.4	142	214
1	4	9	21.2	74.5	115	225
1	4	10	20.1	73.5	122	188
1	4	11	22.2	85.5	135	197
1	4	12	19.1	63.7	101	200
2	1	1	20.2	27.1	125	163
2	1	2	17.1	34.7	121	152
2	1	3	16.1	33.0	124	154
2	1	4	17.0	24.0	120	164
2	1	5	16.3	21.9	134	165
2	1	6	18.4	*	115	*
2	1	7	23.2	30.0	104	150
2	1	8	16.5	24.0	111	161
2	1	9	18.1	36.1	130	160
2	1	10	19.2	29.6	126	148
2	1	11	20.3	31.8	131	190
2	1	12	23.1	39.0	119	180
2	2	1	18.0	34.0	135	176
2	2	2	23.1	38.1	134	174
2	2	3	16.2	27.2	121	152
2	2	4	16.0	31.0	125	136
2	2	5	17.0	26.7	130	185
2	2	6	17.0	23.3	122	130
2	2	7	16.5	28.3	125	144
2	2	8	16.3	25.3	126	160
2	2	9	16.0	27.0	141	171
2	2	10	16.1	31.0	116	136
2	2	11	24.0	*	127	*

Treatment	BL	TN	IW	FW	IH	FH
2	2	12	19.2	36.4	110	155
2	3	1	22.1	35.2	134	154
2	3	2	23.0	*	132	*
2	3	3	20.2	27.9	123	155
2	3	4	22.2	32.3	120	145
2	3	5	18.0	30.0	135	153
2	3	6	16.1	*	126	*
2	3	7	20.2	30.7	143	183
2	3	8	23.3	33.9	130	176
2	3	9	21.0	31.8	123	170
2	3	10	22.4	32.5	140	166
2	3	11	19.0	25.3	125	170
2	3	12	23.1	29.9	115	148
2	4	1	23.0	38.1	120	153
2	4	2	23.3	42.2	125	154
2	4	3	16.0	31.6	104	136
2	4	4	18.1	26.7	101	137
2	4	5	21.0	29.0	100	133
2	4	6	22.2	40.1	112	140
2	4	7	16.2	27.4	105	138
2	4	8	17.4	29.0	96	130
2	4	9	24.1	31.0	130	170
2	4	10	22.0	32.0	129	150
2	4	11	18.3	*	111	*
2	4	12	16.0	23.8	97	110
3	1	1	16.1	20.4	130	144
3	1	2	24.0	26.0	134	147
3	1	3	17.2	21.9	139	154

Treatment	BL	TN	IW	FW	IH	FH
3	1	4	19.5	*	110	*
3	1	5	17.0	23.1	119	128
3	1	6	23.1	*	115	*
3	1	7	17.9	23.0	120	141
3	1	8	24.0	27.0	111	130
3	1	9	20.1	26.0	148	161
3	1	10	16.2	20.0	120	126
3	1	11	17.8	19.2	121	139
3	1	12	17.0	21.8	112	134
3	2	1	16.0	24.5	121	145
3	2	2	20.1	*	105	*
3	2	3	18.2	21.8	104	124
3	2	4	17.1	22.1	130	146
3	2	5	15.9	25.0	135	148
3	2	6	18.0	23.1	131	141
3	2	7	20.8	25.1	109	121
3	2	8	22.0	*	138	*
3	2	9	16.0	18.9	115	124
3	2	10	17.1	20.2	120	135
3	2	11	19.0	23.1	101	117
3	2	12	20.2	24.5	105	121
3	3	1	14.1	17.0	160	183
3	3	2	18.0	*	129	*
3	3	3	21.8	24.4	125	150
3	3	4	20.0	29.2	126	136
3	3	5	16.2	*	125	*
3	3	6	17.1	20.1	124	145
3	3	7	16.0	19.4	110	133

Treatment	BL	TN	IW	FW	IH	FH
3	3	8	22.8	27.1	119	142
3	3	9	23.9	30.6	125	143
3	3	10	24.2	28.2	120	141
3	3	11	20.0	*	105	*
3	3	12	19.1	26.8	123	150
3	4	1	22.7	29.3	115	138
3	4	2	21.2	26.0	104	132
3	4	3	23.0	27.9	110	134
3	4	4	17.1	21.6	105	118
3	4	5	22.0	*	121	*
3	4	6	18.3	23.2	125	142
3	4	7	16.9	20.6	106	122
3	4	8	16.0	20.6	109	131
3	4	9	23.7	27.4	118	146
3	4	10	19.1	*	110	*
3	4	11	20.2	24.9	121	140
3	4	12	17.1	19.5	105	135
4	1	1	23.1	*	134	*
4	1	2	17.0	19.3	115	130
4	1	3	16.1	18.3	116	126
4	1	4	20.9	23.3	135	142
4	1	5	21.8	24.1	101	113
4	1	6	16.0	18.3	109	114
4	1	7	14.2	20.3	110	120
4	1	8	23.8	27.0	126	138
4	1	9	24.0	27.8	134	143
4	1	10	18.1	20.8	121	140
4	1	11	19.0	22.0	125	138

Treatment	BL	TN	IW	FW	IH	FH
4	1	12	22.8	*	136	*
4	2	1	16.0	18.3	110	123
4	2	2	19.1	*	102	*
4	2	3	16.2	*	120	*
4	2	4	19.8	*	119	*
4	2	5	18.1	22.9	120	130
4	2	6	18.0	25.4	114	123
4	2	7	19.3	*	138	*
4	2	8	22.9	26.8	125	133
4	2	9	16.2	19.9	124	134
4	2	10	16.8	20.6	133	146
4	2	11	23.7	26.2	128	140
4	2	12	16.0	19.0	135	142
4	3	1	19.1	22.2	147	158
4	3	2	14.0	17.5	140	156
4	3	3	22.7	26.0	135	142
4	3	4	15.1	19.5	116	123
4	3	5	14.0	*	140	*
4	3	6	18.2	21.7	129	136
4	3	7	23.0	*	102	*
4	3	8	23.7	27.9	125	141
4	3	9	14.1	16.5	146	153
4	3	10	17.0	21.1	131	144
4	3	11	24.0	26.5	146	158
4	3	12	16.1	*	115	*
4	4	1	23.8	*	114	*
4	4	2	16.2	18.7	127	136
4	4	3	18.8	20.7	120	137

Treatment	BL	TN	IW	FW	IH	FH
4	4	4	22.0	25.8	111	120
4	4	5	23.0	26.7	125	139
4	4	6	19.1	21.8	125	136
4	4	7	16.3	18.6	129	141
4	4	8	22.6	23.8	127	146
4	4	9	23.7	*	115	*
4	4	10	15.1	17.5	112	119
4	4	11	17.0	19.5	135	150
4	4	12	19.9	*	123	*

Crataegus monogyna weed control experiment data

BL = Block

TN = Tree number

IW = Initial weight in grammes

FW = Final weight in grammes

* = Dead plant

Treatment 1 - Total weed control

Treatment 2 - Weeds controlled on the 29th June

Treatment 3 - Weeds controlled on the 27th July

Treatment 4 - Weeds present continuously

Treatment	BL	TN	IW	FW
1	1	1	20.2	70.9
1	1	2	27.9	90.2
1	1	3	19.6	55.2
1	1	4	21.4	86.2
1	1	5	24.4	51.2
1	1	6	21.3	61.6
1	1	7	24.0	102.3
1	1	8	25.9	108.2
1	1	9	22.0	68.9
1	1	10	20.3	51.9
1	1	11	17.4	46.7
1	1	12	23.9	53.9
1	2	1	21.9	64.2
1	2	2	27.6	59.5
1	2	3	27.2	80.1
1	2	4	18.8	61.6

Treatment	BL	TN	IW	FW
1	2	5	23.2	57.9
1	2	6	22.6	80.3
1	2	7	26.3	55.0
1	2	8	19.7	62.0
1	2	9	29.2	45.6
1	2	10	28.2	48.3
1	2	11	22.6	51.5
1	2	12	26.3	50.0
1	3	1	22.1	54.6
1	3	2	21.9	42.7
1	3	3	20.7	69.5
1	3	4	26.8	49.2
1	3	5	23.9	60.2
1	3	6	22.1	44.8
1	3	7	19.5	54.8
1	3	8	19.5	54.1
1	3	9	22.6	58.7
1	3	10	18.8	*
1	3	11	21.3	76.2
1	3	12	25.8	71.2
2	1	1	24.4	46.6
2	1	2	19.7	47.9
2	1	3	18.3	37.4
2	1	4	16.3	42.8
2	1	5	24.2	55.9
2	1	6	23.0	36.8
2	1	7	14.5	34.9
2	1	8	22.0	46.2

Treatment	BL	TN	IW	FW
2	1	9	19.1	36.0
2	1	10	23.2	51.4
2	1	11	20.0	22.6
2	1	12	21.6	51.6
2	2	1	19.7	34.9
2	2	2	24.2	46.0
2	2	3	25.3	*
2	2	4	22.1	*
2	2	5	18.8	42.7
2	2	6	21.7	31.7
2	2	7	19.6	26.9
2	2	8	23.5	26.4
2	2	9	21.0	39.4
2	2	10	24.8	37.9
2	2	11	20.0	28.1
2	2	12	18.8	27.3
2	3	1	21.5	38.1
2	3	2	24.8	30.9
2	3	3	18.8	34.8
2	3	4	20.6	54.9
2	3	5	19.2	42.5
2	3	6	14.8	48.7
2	3	7	22.5	34.6
2	3	8	18.3	45.0
2	3	9	24.1	32.6
2	3	10	21.2	42.7
2	3	11	21.9	31.4
2	3	12	22.4	44.4

Treatment	BL	TN	IW	FW
3	1	1	26.4	38.4
3	1	2	21.2	31.0
3	1	3	19.3	36.7
3	1	4	29.9	37.0
3	1	5	21.5	29.8
3	1	6	23.9	35.3
3	1	7	29.3	50.4
3	1	8	30.9	*
3	1	9	23.8	*
3	1	10	24.8	33.1
3	1	11	22.3	47.6
3	1	12	25.2	32.6
3	2	1	21.9	31.3
3	2	2	24.2	48.4
3	2	3	17.4	36.2
3	2	4	17.0	21.6
3	2	5	23.7	*
3	2	6	24.4	26.1
3	2	7	18.9	35.7
3	2	8	22.2	32.3
3	2	9	30.6	*
3	2	10	26.6	33.5
3	2	11	25.3	47.0
3	2	12	22.3	*
3	3	1	17.9	26.2
3	3	2	21.0	34.2
3	3	3	17.9	22.1
3	3	4	20.6	26.0

Treatment	BL	TN	IW	FW
3	3	5	24.2	36.4
3	3	6	30.5	45.4
3	3	7	23.8	40.4
3	3	8	18.2	36.6
3	3	9	17.2	28.5
3	3	10	23.4	34.4
3	3	11	31.9	43.2
3	3	12	31.2	*
4	1	1	20.4	28.7
4	1	2	17.7	*
4	1	3	19.4	27.6
4	1	4	27.9	30.8
4	1	5	21.2	37.0
4	1	6	23.0	*
4	1	7	35.7	45.2
4	1	8	21.5	*
4	1	9	18.9	41.2
4	1	10	18.6	*
4	1	11	19.3	*
4	1	12	18.4	31.7
4	2	1	31.2	33.0
4	2	2	25.5	36.6
4	2	3	21.9	*
4	2	4	24.0	30.9
4	2	5	28.0	*
4	2	6	19.1	*
4	2	7	19.2	37.6
4	2	8	21.9	*

Treatment	BL	TN	IW	FW
4	2	9	21.0	27.0
4	2	10	23.0	*
4	2	11	28.6	32.1
4	2	12	18.6	*
4	3	1	23.3	31.2
4	3	2	32.8	*
4	3	3	20.6	30.6
4	3	4	23.0	*
4	3	5	25.7	31.7
4	3	6	35.5	40.0
4	3	7	19.9	35.0
4	3	8	18.5	20.3
4	3	9	26.8	*
4	3	10	22.4	25.8
4	3	11	18.9	30.9
4	3	12	18.6	28.3

Abies procera water availability data

Group	Plant No.	Init. Height	Yr1.	Yr2.
1	1	70	115	190
1	2	78	108	165
1	3	82	150	228
1	4	87	125	222
1	5	63	112	160
1	6	62	72	129
1	7	65	104	183
1	8	60	110	188
1	9	82	120	178
1	10	60	110	200
1	11	75	120	189
1	12	88	122	190
1	13	64	75	129
1	14	73	125	175
1	15	85	120	192
1	16	78	124	195
2	1	85	120	205
2	2	75	145	260
2	3	60	105	145
2	4	70	118	210
2	5	65	140	214
2	6	70	150	231
2	7	69	128	228
2	8	65	120	181
2	9	65	108	170
2	10	68	106	190
2	11	60	100	165

Group	Plant No.	Init. Height	Yr1.	Yr2.
2	12	100	121	236
2	13	80	133	215
2	14	60	120	224
2	15	78	89	155
2	16	70	115	184
3	1	70	121	178
3	2	66	94	170
3	3	62	108	168
3	4	83	118	186
3	5	90	158	240
3	6	73	130	221
3	7	70	94	135
3	8	62	120	225
3	9	78	133	222
3	10	83	130	187
3	11	78	125	184
3	12	100	155	224
3	13	93	153	210
3	14	70	136	225
3	15	70	93	157
3	16	77	118	192
4	1	95	150	211
4	2	86	136	*
4	3	100	148	212
4	4	90	130	180
4	5	90	134	208
4	6	95	142	165
4	7	68	95	112

Group	Plant No.	Init. Height	Yr1.	Yr2.
4	8	73	115	161
4	9	85	122	188
4	10	60	94	117
4	11	60	140	180
4	12	65	127	210
4	13	80	117	183
4	14	70	88	*
4	15	62	91	126
4	16	71	104	172

Fraxinus excelsior water availability data

Group	Plant No.	Yr1.	Yr2.
1	1	58	176
1	2	68	154
1	3	66	169
1	4	51	270
1	5	51	175
1	6	70	186
1	7	63	334
1	8	56	196
1	9	71	213
1	10	68	256
1	11	74	295
1	12	58	221
1	13	52	261
1	14	76	237
1	15	79	305
1	16	63	340
1	17	68	283
1	18	63	278
1	19	85	316
1	20	78	386
1	21	68	227
1	22	70	237
1	23	77	250
1	24	75	264
1	25	78	190
1	26	69	230
1	27	72	210

Group	Plant No.	Yr1.	Yr2.
1	28	65	350
1	29	55	255
1	30	54	280
2	1	98	281
2	2	85	209
2	3	103	260
2	4	106	265
2	5	96	279
2	6	80	244
2	7	105	301
2	8	114	306
2	9	110	230
2	10	103	277
2	11	113	245
2	12	94	275
2	13	85	298
2	14	94	248
2	15	130	261
2	16	90	360
2	17	102	297
2	18	78	300
2	19	115	328
2	20	95	303
2	21	88	225
2	22	111	385
2	23	84	324
2	24	86	304
2	25	90	426

Group	Plant No.	Yr1.	Yr2.
2	26	85	160
2	27	93	294
2	28	88	238
2	29	114	346
2	30	79	342
3	1	138	470
3	2	156	347
3	3	169	380
3	4	173	423
3	5	172	328
3	6	167	340
3	7	155	300
3	8	135	490
3	9	168	340
3	10	143	470
3	11	146	400
3	12	124	366
3	13	115	420
3	14	100	510
3	15	172	500
3	16	134	457
3	17	163	377
3	18	128	368
3	19	133	502
3	20	170	494
3	21	138	460
3	22	161	390
3	23	182	388

Group	Plant No.	Yr1.	Yr2.
3	24	138	396
3	25	143	359
3	26	163	444
3	27	171	526
3	28	152	316
3	29	138	400
3	30	173	279
4	1	120	146
4	2	89	154
4	3	102	139
4	4	94	270
4	5	112	175
4	6	98	186
4	7	90	334
4	8	107	625
4	9	110	584
4	10	111	321
4	11	135	412
4	12	121	221
4	13	115	261
4	14	126	795
4	15	136	356
4	16	115	525
4	17	120	290
4	18	123	278
4	19	126	316
4	20	120	471
4	21	120	490

Group	Plant No.	Yr1.	Yr2.
4	22	104	300
4	23	97	347
4	24	118	264
4	25	110	190
4	26	99	230
4	27	106	410
4	28	111	450
4	29	113	255
4	30	100	280

THE USER MANUAL FOR THE UNIVERSITY OF BATH MICRO-COMPUTER BASED SITE, SOIL AND PLANT ASSESSMENT MODEL

CONTENTS

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Author F. Hope 1987-1990.

UNIVERSITY OF BATH MICRO-COMPUTER BASED

SITE, SOIL AND PLANT ASSESSMENT MODEL

1. Introduction :

When 8 bit micro-computers first became readily available in the late 1970's they were expensive, had poor graphic capabilities, relatively slow operating speeds and small amounts of Random Access Memory (RAM). Their mass storage devices, e.g. "Floppy" disc drives and "Winchester" hard discs, had relatively low capacity, slow data transfer rates and severe reliability problems. Today's modern computers on the other hand, are based around 16 or 32 bit micro-processors, have large amounts of available RAM, high resolution colour monitors and reliable, fast high capacity storage media. The development of modern micro-computers has meant that programmers are now able to develop large, fast running, sophisticated programs, which would have been impossible 10 ten years ago.

The University of Bath micro-computer based site assessment and plant establishment model has been developed by Frank Hope and Peter Thoday. It has been implemented on a Victor V286C 16 bit micro-computer with an Enhanced Graphics Adapter(EGA) colour monitor, a 30 megabyte hard disc, a single high density 5¼ inch "Floppy" disc drive, and 640K bytes of Random Access Memory (RAM). The model will run on almost any IBM compatible computer as long as a colour EGA monitor, a hard disc and at least 512K of RAM are available, however, for optimum speed of operation it should only be run on systems based on Intel's 80286, or faster compatible micro-processors.

The model allows the user to identify a large range of climatic and site related features which are known to affect the initial establishment and subsequent growth of plants. The climatic data have largely been based on Meteorological Office information, whereas the majority of the soil and site related data have been collated from records of The Soil Survey Of England and Wales.

In addition to being able to identify site characteristics the model also allows the user to select taxa which will establish and grow in specific site conditions. The plants available for comparison have been extracted from the Joint Council of Landscape Industries plant list, and the data relating to each have been collated from a range of standard horticultural reference works.

2. Introduction to climate related features.

England and Wales have been divided into a total of 70 climate related reference areas, as illustrated in Appendix A, Fig. 1. To find out which area your planting site is in, you must first use the relevant 1:50,000 Ordnance Survey Landranger map to locate its grid reference, and then, using the appropriate location map (Appendix A, Figs. 2 to 11) plot its position and altitude. The zone in which it is located is the reference area for your climate related enquiries.

To assist you the model has been pre-programmed with reference area information (relating to the mean altitude of the zone) for all English and Welsh towns/cities listed in the 1972-1973 Whitaker's Almanacs, i.e. prior to local government re-organisation (see appendix B). This means that if your planting site is in one of the pre-recorded locations all you need do is assess the site's altitude and the computer will carry out all other necessary calculations. The model will also allow new reference data to be added to the files, which means that you can store information about unrecorded sites.

2.1 Climate related corrections.

A number of the climate related parameters, e.g. air temperatures and annual rainfall, are affected to some degree by altitude, coastal proximity and exposure. The model allows you to modify each of these to suit specific conditions.

2.1.1 Altitude.

As altitude increases climatic changes occur which can adversely affect the growth and establishment of plants. The most important of these changes are a lowering of air and earth temperatures, higher rainfall, a shortening of the growing season and a potential increase in the frequency and severity of ground and air frosts. Taxa which are not frost hardy may be severely damaged or even killed at relatively low altitudes, especially when grown in exposed situations.

When a location is initially selected the model displays the maximum, minimum and mean altitudes for the climatic zone. All of the initial altitude data for the pre-recorded locations have been based on the mean zonal altitude figure, although you are at liberty to modify it within the maximum and minimum range.

2.1.2 Proximity to the coast.

In general, coastal regions of England and Wales exhibit a more equable climate than inland areas, i.e. daily maximum temperatures are lower whilst nightly minimum temperatures are higher. Sunshine and radiation are strongest in coastal localities which lead to high values of potential transpiration. In exposed coastal situations strong salt laden sea breezes can reduce establishment and growth of young plants, whereas established taxa can exhibit considerable malformed growth.

No pre-recorded climatic data for coastal proximity is available, but as with altitude, you are at liberty to select a coastal proximity modification factor which highlights sites within 3 kilometres of the sea. The pre-recorded plant lists do contain a rating for coastal site intolerance. These ratings identify taxa which are unsuitable for planting in coastal locations.

2.1.3 Site exposure.

In exposed situations plant establishment and growth may be adversely affected. The major causes of damage being excessive amounts of transpiration and physical buffeting, both of which become more pronounced with increasing air speeds and altitude.

The exposure rating of each zone has been extracted from the "Bioclimatic Classification" map supplied by the Soil Survey of England and Wales. The degree of exposure within individual zones can vary considerably, which means that the initial rating is only a broad estimate. The model does allow the exposure rating to be set to one of the following conditions :

1. Very Sheltered sites.

2. Sheltered sites.
3. Exposed sites.
4. Very exposed sites.

2.2 Major climate related criteria.

The assessment model contains 16 major climatic criteria, the first eight of which can display data, in histogram form, relating to the year as a whole, or be divided into both the growing and dormant seasons. None of these yearly displays are affected by modifications to the model's climate, although a further set of histograms is related to the means of all other zones. The second group of eight criteria display individual pieces of information, again in histogram form, but this time only in direct relation to the maximum, minimum and means of all the other zones. These displays are altered whenever the model's climate is modified by the user. The climatic criteria are as follows :

1. Air temperature.
2. Earth temperature.
3. Zonal rainfall.
4. Potential transpiration.
5. Sunlight.
6. Daylength.
7. Solar radiation.
8. Illumination.
9. Accumulated day degrees above 10 degrees centigrade.

10. Accumulated day degrees below 0 degrees centigrade.
11. Last expected spring frost.
12. Effective transpiration.
13. Soil moisture deficit.
14. End of soil moisture capacity.
15. Return to soil moisture capacity.
16. Excess winter rain.

2.2.1 Air temperature.

The assessment model displays monthly mean air temperature readings for each of the 70 climatic zones. The data have been collated using Meteorological Office data for the 30 years between 1941 - 1970, and are accurate to within plus or minus 1 degree centigrade. The data are further sub-divided to highlight mean air temperatures for both the growing and dormant seasons, and give a comparative view of individual zones as compared to the average over England and Wales.

2.2.2 Earth temperature.

The mean earth temperatures for the 70 climatic zones have been collated from Meteorological Office data. The temperatures were measured by suspending a thermometer in a metal tube which was sunk vertically in the ground, in such a way that the thermometer bulb was 30cm below the surface of closely cropped grass. The model displays the data in exactly the same way as for air temperatures (see 2.2.1).

2.2.3 Zonal rainfall.

Rainfall varies considerably with height and location; higher areas to the west receiving much greater quantities than in the south eastern parts of the country. The assessment model uses rainfall averages for the 30 year period between 1941 - 1971 to indicate the mean rainfall for each of the 70 climatic zones.

2.2.4 Potential transpiration.

The highest values for potential transpiration are usually found in coastal areas where the sunshine and radiation are stronger than in more inland localities, although large fluctuations can occur with respect to a specific site's altitude. The assessment model uses potential transpiration figures derived from Meteorological Office data; they are estimated to be reliable to within plus or minus 2mm. Potential transpiration during the growing season gives some indication of photosynthetic potential, but it does not take into account any limitations arising from a shortage of moisture or nutrients.

2.2.5 Sunlight.

The assessment model displays the mean daily hours of bright sunshine, as measured by means of a Campbell-Stokes recorder, for each of the 70 climatic zones. The data have been derived from the Meteorological Office's 30 year measurements between 1941 - 1971 and are estimated to be accurate to within plus or minus 0.1 hours per day in winter, and approximately plus or minus 0.2 hours per day in summer. The amount of direct sunlight falling on individual sites can be affected by the presence of large quantities of industrial smoke, topography, or shadows from tree shelter belts and nearby buildings. It has been estimated that a reduction of approximately 10 percent may result in such adverse conditions.

2.2.6 Daylength.

Each of the 70 climatic zones contains a figure for estimated daylength. The figure has been abstracted from Reed's Nautical Almanac and relates to the mid latitude points for each of the zones. The figures are expressed in units of hours and tenths of hours, i.e. not hours and minutes. The assessment model allows you to display estimated daylength figures for any pre-recorded location, and to compare daylengths of various locations.

2.2.7 Solar radiation.

The data relating to Solar radiation consists of two sets of figures each of which is displayed separately. The first display highlights the data in milliwatt-hours per square centimetre, whereas the second displays it in watts per square metre. The model does allow you to modify the solar radiation data by selecting climatic modification factors, such as coastal proximity and altitude.

2.2.8 Illumination.

The assessment model figures relating to Illumination are displayed in units of kilolux-hours. The types of display are the same as for solar radiation, as are the user available modification factors.

2.2.9 Accumulated Day degrees above 10 degrees centigrade.

Accumulated Day degree temperature figures can be obtained by daily site measurements, or by the use of specialised mathematical formulae. They are affected by a number of climatic factors, for example, a modification of approximately 90 day degrees can be made for each 100 metre altitude rise or fall. The assessment model utilises data extracted from Meteorological Office records and displays it in histogram form. Day degrees, when related to other climatic factors such as exposure, are useful for assessing plant development and for calculations relating to heating requirements of buildings such as glasshouses, although they can produce inaccurate figures if used by themselves.

2.2.10 Accumulated Day degrees below 0 degrees centigrade.

Accumulated day-degrees below 0 degrees centigrade are useful for estimating the hardiness of plants, although calculated figures can vary significantly especially in coastal regions, or with increasing altitude. There can also be large discrepancies on sites with restricted air movement, e.g. frost pockets.

2.2.11 Last expected spring frost.

An accurate estimate of when the last spring frost for any particular site will occur is almost impossible to achieve. The reason for this is that localised factors such as exposure, wind channels, type and height of vegetation, soil type, altitude, and coastal proximity can all, to a greater or lesser degree, affect the amount of frost a site receives. The assessment model does contain a broad estimate of when the last spring frost in each of the 70 climatic zones is expected, although it must be remembered that localised conditions will seriously affect the actual timing.

2.2.12 Effective transpiration.

The figures for potential transpiration (see 2.2.4) during the growing season are not affected when summer soil moisture deficits occur, which means that misleading figures can be produced. The calculation of effective transpiration, however, does make an adjustment for absence of adequate soil moisture. It is achieved by only summing potential transpiration figures when less than 50mm of soil moisture deficit occur in the main root zone of the soil. In practical terms this means that a meaningful figure for transpiration during the growing season can be obtained which is unaffected by moisture deficits or soil temperature.

2.2.13 Soil moisture deficit.

During the growing season the rate of water loss from the soil usually exceeds the rate of replenishment, which means that less water is available for use by plants. A soil moisture deficit occurs when the soil moisture content is below field capacity. The amount of deficit is usually described in precipitation terms. This means that a deficit is equal to the amount of water, i.e. rainfall or irrigation, necessary to bring a soil back to field capacity.

2.2.14 End of soil moisture capacity.

Until the end of march of each year the amount of average rainfall exceeds transpiration in almost all lowland areas of England and Wales; by April they are approximately equal, but by the end of May transpiration usually exceeds rainfall.

The assessment model displays an approximation of when transpiration can be expected to exceed rainfall. The actual figure for any location will vary with local conditions, for example, there will be approximately 1 days delay for every 10 metres increase of altitude in the north west of England.

2.2.15 Return to soil moisture capacity.

The time of the year when a soil is returned to field capacity by rainfall regulates the timing of site operations and the type of plant which can be successfully grown. Sites which return to capacity early in the season are liable to structural problems and can be prone to seasonal waterlogging. Soil preparation and planting time can be severely limited, and maintenance schedules can be extremely difficult to organise. The assessment model displays, for each of the 70 climatic zones, a prediction of when a soil will be returned to field capacity.

2.2.16 Excess winter rain.

Any water which falls on a site after field capacity is reached is lost through evaporation, transpiration and drainage, otherwise it is retained on the soil surface as puddles. The amount of excess winter rain is calculated by totalling all the water a site receives after field capacity is reached, minus a figure for evaporation and the amount transpired from any plants on the site. The amount of excess winter rain has a direct effect on the selection of plants for a site. High amounts will lead to possible waterlogging, leaching of nutrients, poor soil structure and lack of adequate aeration.

3.0 Introduction to soil and site related criteria.

In addition to displaying information relating to climate the assessment model also allows you to specify, and modify, up to 15 soil and site related criteria. The list of selection criteria is as follows :

1. Soil textural group.
2. Soil depth.
3. Drainage characteristics.
4. Groundwater effect.
5. Slope.
6. Possibility of erosion.
7. Soil structure.
8. Presence of soil pan.
9. PH rating.
10. Organic matter content.
11. Calcium carbonate content.
12. Soil nutrient status.
13. Artificial protection.
14. Weed control.
15. Artificial irrigation.

3.1 Soil textural group.

Soils consist of 6 main constituents, i.e. mineral matter, organic matter, soil air, soil water, flora and fauna. The mineral matter consists of particles of clay, silt, sand, gravel and larger stones, all of which are found in varying quantities. The proportions of clay, silt and sand are used to place individual soils into different textural classes. The assessment model automatically loads textural data relating to the soil type of the selected location, although you are at liberty to modify the selection as and when required. The textural selection options are as follows :

1. Loamy.
2. Clayey.
3. Silty.
4. Sandy.
5. Peaty.
6. Rubble, Spoil and Waste, i.e. analogous to many contemporary building and landscape sites.

3.2 Soil depth.

The depth of a soil affects the anchorage of plants and the extent to which roots can forage for water and nutrients. Shallow soils, which may be either natural or man made, can severely inhibit plant establishment and subsequent growth. A small number of taxa can tolerate shallow soil conditions, but the majority grow best when the soil is deep. The assessment model allows you to categorise the soil into one of the following soil depth ratings :

1. Deep soil.
2. Shallow soil.

3.3 Drainage characteristics.

Soils containing a high proportion of clay have a tendency to retain a relatively large percentage of water, which is released over a long period of time. When this occurs the soil is said to be slowly permeable. Sandy soils on the other hand, release their water far more readily than clays, and are usually free draining, or extremely free draining. Most taxa prefer to grow on sites which are free draining, although a number will tolerate slowly permeable and extremely free draining soils. The assessment model allows you to specify one of the following drainage conditions :

1. Well drained soils.
2. Slowly permeable soils.

3.4 Groundwater effect.

The term "Groundwater effect" is used to describe the position of the water table in relation to the topsoil. Permanently high water tables can produce water-logged soil conditions, whereas variable tables can often lead to seasonal waterlogging. On modern landscape sites, where conditions are often far from ideal, it is possible to produce an artificial "Perched" water table by smearing part of the sub-surface layers of the soil. When a soil is water-logged all the spaces between the particles are full of water and all the soil air is driven out. If prolonged, this leads to the development of anaerobic conditions in which few plants can survive. The assessment model allows you to select from one of the following ground water effect options :

1. No groundwater problem.
2. Water-logged conditions.
3. Seasonally water-logged.

3.5 Slope.

The slope of a site affects the drainage characteristics of the soil, the amount of soil erosion which may take place and the ease of maintenance. Steep slopes can be extremely free draining, and where erosion has taken place, the topsoil can be very shallow. The assessment model allows the selection of one of the following slope options :

1. Flat land.
2. Steep slopes.

3.6 Possibility of erosion.

The two main causes of erosion in England and Wales are wind and water, although the location, the specific soil type and the soil management can have a large influence on when, and if, erosion takes place. On exposed coastal, or steeply sloping land, both rain and wind can cause severe erosion, whereas the sides of river banks are carried away with the natural movement of the water. Where "open" soils, e.g. well drained sands and peats, coincide with exposed conditions severe wind erosion can take place; in severe cases topsoil in excess of 25mm can be removed within a few minutes. The assessment model allows the selection of one of the following options relating to the likelihood of soil erosion :

1. No erosion problem.
2. Possible erosion problem.

3.7 Soil structure.

The term "Soil structure" is used to describe how soil particles and organic matter are joined, or cohere together. The importance of soil structure lies in the fact that it largely controls the pore spaces within the soil, which in turn controls drainage characteristics, available moisture and soil air. Some soils, e.g. heavy clays, have an inherently weak structure, whereas others, e.g. well drained loams, are usually far more stable. The assessment model allows you to select from one of the following options :

1. Well structured soil.
2. Poorly structured soil.

3.8 Presence of soil pans.

Pans can be produced either naturally, by the downward movement of chemicals, e.g. iron and aluminium, or artificially by the incorrect management of the soil. In certain soils, characterised by Podzols, chemical elements are moved from the upper to lower horizons where they join together to form a solid, impervious layer; commonly known as an "Iron pan". Man made pans, often named "Plough pans", can be produced on other soils, especially those with a high clay content.

Plough pans are formed by "smearing" the soil during cultivations, e.g. ploughing, at a constant depth. Where soil pans exist the establishment and subsequent growth of plants may be severely restricted. The main reasons for this being that the pans restrict the movement of soil moisture and air, and can prevent to downward growth of plant roots. The assessment model allows the selection of either of the following options relating to soil pans :

1. No pans present.
2. Pans present.

3.9 PH rating.

The pH scale is used to give an indication of how acid or alkaline a soil is. The scale runs from 0 to 14. A rating of 7 is classed as being neutral; figures below 7 indicate acidity, whereas figures above 7 indicate alkalinity. The vast majority of plants will survive in a wide range of pH, with problems only arising in extreme acidity or alkalinity. There are, however, species which will tolerate both extremes of pH. The assessment model allows you to specify one of the pH ratings listed below. The first option is where the majority of plants should be classified, options 2 and 3 should be selected where extreme pH conditions exist. The model also allows you to identify taxa which are intolerant of extreme pH's. The selection options are as follows :

1. Slightly acid soils.
2. High pH.
3. Low pH.

3.10 Organic matter content.

Organic material has a number of contrasting effects in the soil. It releases nutrients for plant growth, it aids in the retention of soil moisture, increases cation exchange capacity and helps in the stabilisation of soil structure. Many modern landscape sites have de-natured soils which may become rock hard when dry, or boggy when wet. The application of bulky organic matter on these sites can provide a means of actually opening up the soil to allow drainage to take place and oxygen to enter. The assessment model allows you to specify one of the following organic matter contents :

1. Low organic matter.
2. Moderate organic matter.
3. Farm yard manure recently applied.

3.11 Calcium carbonate content.

Chalk is present in considerable quantities over a large area of southern Britain, and when found close to the surface it can make soils alkaline in nature. Shallow topsoils overlying calcium carbonate sub-soils tend to be low in available nutrients and have a poor inherent structure. The management of these soils can be extremely difficult as when wet they become very sticky, whereas when dry they tend to become hard and crack. The assessment model recognises the following soil calcium content ratings :

1. Non-calcareous soil.
2. Calcareous soil.

3.12 Soil nutrient status.

Soils vary considerably in their natural nutrient status. Coarse sands have a low status whereas clays, loams and organic soils are usually high. Soil management and previous cropping will also have a major contributing effect on nutrient levels; intensive cropping, especially monocrop situations, being particularly bad.

Before planting takes place it is always beneficial to have a soil analysis carried out. This will indicate any deficiencies, and form the basis of a coherent fertiliser plan. Most analyses are based on ADAS indices; a nutrient level of index 0 being very low, and an index of 3, or 3+ being high. The assessment model allows you to specify the nutrient status of the soil using one of the following ADAS nutrient indices :

1. Index 0.
2. Index 1.
3. Index 2.
4. Index 3+.

3.13 Artificial protection.

Horticulturalists have recognised for many years the benefits of providing young transplants with some form of artificial protection, although it is only relatively recently that landscapers' have had suitable materials to provide protection on a large scale. Modern plastic protective shelters provide a micro-climate which aids in the establishment and subsequent development of newly planted stock. They can reduce the adverse effects of severe exposure and coastal proximity, minimise the risk of taxa being sprayed with harmful chemicals and prevent attacks from animals. The assessment model allows you to select one of the following options :

1. No protection given.
2. Plant shelters used.

3.14 Weed control.

Weeds adversely affect plants by competing directly for water, light and nutrients, and indirectly by harbouring pests and diseases. Young transplants can be severely checked, or even killed, if weeds are allowed to compete during the first few years of their life. Whenever possible a square metre of soil around young transplants should be kept clear of weeds throughout the first two or three growing seasons, although where this is impracticable smaller areas, or maintaining weed free sites for less than a full season, will still be beneficial. The assessment model allows the selection of the following options :

1. No weed control given.
2. Control given until the mid-June.
3. Control given until mid-July.
4. Total weed control.

3.15 Artificial irrigation.

Newly planted transplants often suffer due to the lack of obtainable moisture. The problem usually exists because either the plant is devoid of some of its root system, the soil is structureless or too dry, or the planting site is exposed which leads to excessive amounts of transpiration. In high rainfall areas, such as many parts of North Wales, artificial irrigation is unnecessary as growing season soil moisture deficits (SMD) rarely occur. On the eastern side of the country, however, for example East Anglia, large growing season soil moisture deficits occur every year and in these locations artificial irrigation is almost always beneficial. Recommendations for artificial irrigation are normally given by stating the amount of water to apply at a given growing season soil moisture deficit. The assessment model recognises two irrigation options, these are :

1. No irrigation given.
2. 25mm of water applied at a 75mm deficit.

4.0 Introduction to the Soil Survey of England and Wales data.

The Soil Survey of England and Wales publish a series of 1:250,000 soil maps which describe the various types of soil found in England and Wales. There are a total of 297 soil types which are differentiated by observable, or measurable features of the soil profile. Many landscape sites, especially in large towns and cities, have soils which have been modified to such a degree that they should be classed as "Man Made". In these situations the Soil Survey data will not give a representative picture of the local soil characteristics; a more reliable method would be to carry out a full textural and chemical analysis. However, to aid the user, the model has been programmed with information relating to nearest known soil type for each of the pre-recorded locations. The model also stores generalised data relating to each of the 297 soil types; the information being stored under the following general headings :

1. Map symbol and sub-group.
2. Soil association.
3. Ancillary sub-groups and soil series.
4. Geology.
5. Soil and site characteristics.
6. Cropping and land use.
7. Area covered in km^2.

5.0 Notes and recommendations.

Having selected the climatic zone and soil characteristics the user is supplied with a series of notes relating to the specific site. The information displayed will vary depending upon complex climatic and site relationships - a total of over 50 notes being available for display. Some of the notes give recommendations relating to items such as detailed fertiliser application, whereas others, for example altitude notes, simply highlight potential problems.

6.0 Horticultural aspects.

Once the climatic and site related features have been specified the assessment model will allow you to match one of the pre-programmed taxa to the site. The first thing the model does is to make an assessment of the potential hardiness of the selected plant. It does this by checking various climatic criteria and by searching a pre-programmed list of approximately 1000 potentially tender plants. The model also holds information relating to all the taxa listed in the Joint Council of Landscape Industries plant list. Each plant record contains data on the following possible soil and site intolerances :

1. Soil texture.
2. Soil depth.
3. Soil moisture.
4. Soil pH.
5. Maritime conditions.
6. Site exposure.
7. Seasonal waterlogging.
8. Potential for late spring frost damage.

7.0 Care and maintenance of the programs and data.

Initially, the micro-computer based assessment model consists of the following :

A. A 360k floppy disc containing the assessment model programs and batch files.

B. A 360k floppy disc containing climatic data-files.

C. A 360k floppy disc containing data relating to Soil Survey of England and Wales soil maps.

D. A 360k floppy disc containing Plant intolerance data.

E. A 360k floppy disc containing a tender species data-file.

F. A manual outlining the use of the package.

7.1 Micro-computer configuration.

The following is a list of the minimum equipment necessary to operate the model :

A. A Victor V286C or other IBM compatible computer.

B. A minimum of 512k of Random Access Memory (RAM).

C. At least 1 - 360k floppy disc drive.

D. A minimum of 10 megabytes of hard disc storage.

E. A suitable printer (not essential but beneficial).

F. The discette containing the master programs.

G. The discettes containing the data-files.

H. The correct manuals for the computer.

The assessment model has been designed to display data in high resolution, which means that for optimal use the micro-computer should have a colour Enhanced Graphics Adapter (EGA) monitor. The Victor V286C 16 bit micro-computer is based on the Intel 80286 micro-processor running at 10 MHz. It is compatible with the Intel 8086/8088 processors, but is much faster in operation. The assessment model is designed to run on the Intel 80286 or faster compatible micro-processor, it will run on 8086/8088 based systems, but the speed of operation will be greatly reduced.

7.2 Making BACKUP copies of the diskettes.

The Assessment model is available on 5¼ inch IBM format floppy discs. Before you use the programs you must ensure that suitable BACKUP copies are produced. The method of producing BACKUP copies will vary with the specific computer configuration. To make copies of the discettes using a twin disc system carry out the following :

1. Format your destination discs, i.e. the discs which you are going to make your copies onto.
2. Log on to drive -A-.
3. Place the master program disc into drive -A- and a blank formatted disc into drive -B-.
4. Close both drive doors.
5. Type the following command, and when finished press the RETURN key. COPY a:*.* b:
6. Repeat the operation for each of the discs to be

copied.

Method for a single floppy disc and a hard disc :

1. Log on to drive -C- i.e. the hard disc, by typing c:
2. Create a temporary sub-directory with any suitable name. From the root directory this can be performed as follows : md copy (this will create a sub-directory called COPY)
3. Log on to the temporary directory by typing cd\copy
4. Log on to drive -A- by typing a:
5. Copy all the programs or data-files from drive -A- to the temporary directory by typing copy *.* c:
6. Remove the master discette from drive -A- and replace it with a blank formatted discette.
7. Log on to the sub-directory by typing c:
8. Copy all the programs from the temporary sub-directory to drive -A- by typing copy *.* a:

For more information relating to making copies of discettes see your user manual under the headings of BACKUP and COPY.

Please note that this manual and accompanying software have taken a considerable amount of time, energy and money to produce. You are asked to make only essential BACKUP copies, and to destroy such

copies, or return them with the masters, at the termination of each session. DO NOT MAKE BACKUP COPIES AND GIVE THEM TO FRIENDS.

7.3 Care of the programs and data.

Always try to store the program floppy discettes in a cool dry place, preferably in their storage boxes, or in a suitable plastic cover. Keep them away from magnetic fields, clear of dust/grit, and do not touch the magnetic surfaces with your fingers. Before making copies of your original discettes ensure that a "Write Protect Tab" is placed over the rectangular cut-out situated on the right hand side of the discettes. This will prevent you from accidentally deleting or corrupting the programs and data.

Once you have at least one BACKUP copy of the programs and data-files you should store your originals away somewhere safe and always use the BACKUP copy. Then, if for any reason your programs or data are damaged, you can make new copies from the originals.

One final point, if you make changes or additions to the data-files, make frequent BACKUP copies of your data discettes and always ensure that each copy is labelled correctly, i.e. showing the type of data and the date when it was stored.

8.0 Getting started.

Before the programs can be used the computer must be set up at its correct site and any "peripherals", such as printers and plotters, must be plugged in.

8.1 Setting up the machine.

This manual outlines the use of the assessment model programs on a "VICTOR V286C" micro-computer with 640K of RAM memory, one 5¼ inch high capacity disc drive, a 30 megabyte hard disc and an IBM enhanced graphic adapter (EGA) monitor. Other configurations of IBM compatible micro-computers will work in exactly the same way, although certain minor differences in keyboard lay-out, and the production of BACKUP copies may exist. For more information see the user guide which came with your computer.

Before the programs can be used the computer should be set up and switched on. The manuals supplied with the computer will describe the correct method, but to assist you a "potted" version for the Victor V286C is outlined below.

1. Place the computer on a firm level surface, away from direct sunlight, and assemble it correctly, e.g. ensure that the dip switches on the monitor are set correctly.

2. Plug the computer into a suitable electric socket.

3. Open the Floppy Disc drive door, i.e. the switch on the disc drive should be horizontal. Ensure that there are no protective cards in the drive.

4. Switch on the monitor and then the computer. The indicator lights for both should light up and a system checking routine should indicate that the system is functioning correctly.

8.2 Copying the programs onto the hard disc.

Before you can run the assessment model on your computer all of the programs and data-files must be transferred from the floppy discettes onto your hard disc. To complete this task carry out the following procedure :

1. Open a sub-directory on your hard disc. You can call it whatever you wish as long as the name follows the computer's naming conventions.

2. Copy all of the programs and data-files from the various discettes into your sub-directory.

3. A batch file entitled "Go.bat" is provided on the original program disc. You can place this in the ROOT directory of your computer, i.e. the directory that is entered when you originally switch on the computer. Once the batch file and all of the programs and data are copied all you need do to run the programs is type GO followed by pressing the RETURN or

ENTER key.

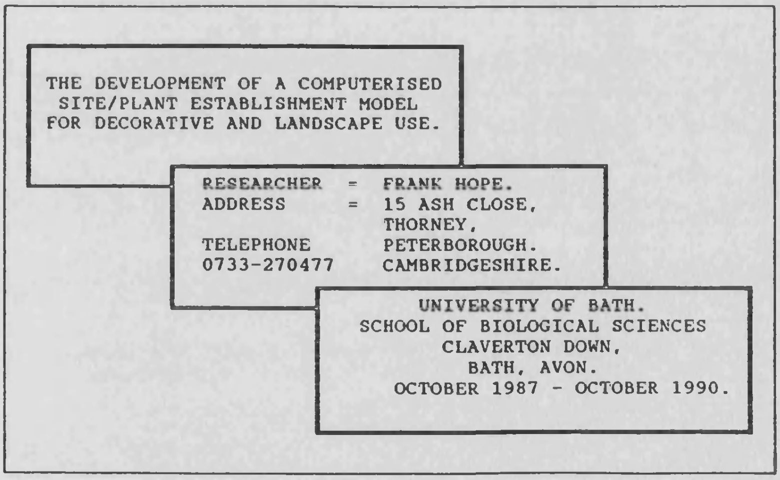
If you would like the program to run automatically whenever you switch on the computer all you need do is call up the GO.BAT batch file from within the AUTOEXEC.BAT batch file located on your ROOT directory. If no such file exists consult your user manual on how to produce one.

Please note, the assessment model will only run correctly when installed on a hard disc computer system. The individual programs will run on Floppy discs, but some of the data-files are extremely large, and on small capacity Floppy disc based systems they will be unavailable for use.

9.0 Introduction program (Master Program Menu).

Assuming that you have inserted the GO.BAT command in the AUTOEXEC.BAT batch file on the root directory, once you switch the computer on an automatic testing sequence will take place. After checking that everything is working correctly the computer will assume overall control and load the assessment model's Introduction program. This consists of an introductory screen (Fig. 1) outlining the researcher's name and address, and the address of the University of Bath.

Fig. 1 INTRODUCTION TO THE PROGRAM.



If you intend to use the program without automatically loading it from the root directory you should log into the sub-directory containing the programs and data-files and use the GO.BAT batch file to enter the Introductory program.

Should you wish to run the programs without using the GO.BAT batch file, simply log on to the correct sub-directory containing the programs and data-files and type the following command sequence:

GEMVDI/MENU

After a few moments the initial screen will clear and the program will display a copyright notice and a "MENU" (see Fig. 2) of available options.

Fig. 2 MAIN PROGRAM MENU.

```
SITE/PLANT ESTABLISHMENT MODEL (COPYRIGHT F.HOPE 1989)
======================================================
                 ALL RIGHTS RESERVED

        1.  ENTER SITE/ESTABLISHMENT MODEL.
        2.  ENTER DATA MODIFICATION PROGRAM.
        3.  RETURN TO DISC OPERATION SYSTEM.

 TYPE THE PROGRAM NUMBER, THEN PRESS THE <RETURN> KEY
```

The options are as follows :

1. Enter the site/assessment model.
2. Enter the data modification program.
3. Return to the disc operating system.

The first option loads and runs the Site and Establishment model. The second allows you to enter new, or modify existing data, and the third closes all data-files and returns you to the C> prompt of the disc operating system (DOS); in this case MS-DOS written by the Microsoft Corporation.

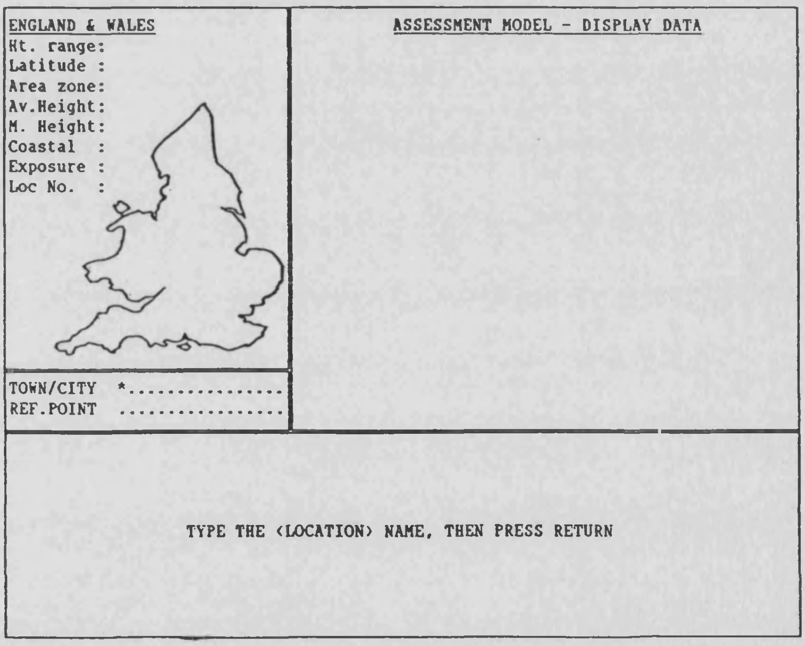
When you return to the disc operating system the site assessment and plant establishment model will be terminated and all the data-files will be closed. If you have modified any of the data now would be an ideal time to make some BACKUP copies of the data-files. You can do this directly using the COPY or BACKUP routines from DOS, or enter a series of commands into the GO.BAT batch file, so that a BACKUP routine is started automatically after each termination of the model.

9.1 Making a selection.

At the base of the Main Program Menu screen (Fig. 2) a "PROMPT MESSAGE" line will ask you to enter the number relating to the option you require. You simply type the number adjacent to the program you wish to run, and then confirm your selection by pressing either the <RETURN> key or the <ENTER> key - they both have the same effect. Each screen of the assessment model will display some form of prompt message outlining the available options and keys, although at certain points you will find that some keys become unavailable. Don't worry, this is simply to prevent you from making accidental mistakes.

You will find that the computer controls the availability of keys and that all important ones will be switched on and off as required. The only key available at the Main Program Menu prompt, other than the keys mentioned above, is <ESC> - which is short for ESCAPE. This key, found at the top left hand corner of the keyboard, is a "CANCEL" key which if pressed at this point will return you directly to DOS in the same manner as option 3 of the menu. The <ESC> key is available throughout the assessment model, although in the majority of cases it usually returns you to the "Main Program Menu" (Fig. 2) and not directly to DOS.

Fig. 3. THE SITE\ESTABLISHMENT MODEL.



10.0 The site/establishment assessment model.

Option number 1 of the Main Program Menu, i.e. Enter the Site / Assessment Model, will load and run the Site and Establishment program (Fig. 3). This allows you to specify and view all climatic and site related data for each of the 70 climatic zones, or any two of the 576 pre-recorded locations (Appendix B). Using this program you will also be able to assess whether or not a plant will be suitable for a range of specific growing conditions.

When the program is initially loaded the screen (Fig. 3) displays areas relating to the selection of climatic criteria. It will outline the following information :

1. A map of England and Wales which will be used to highlight the location of your selected sites. It does this by displaying a rectangular block at the approximate locations.

2. A list of site related headings which will display data about the selected locations.

3. An area to display a wide range of data (Main Display Area). This area will be used to display almost all of the climatic, site and taxon related information.

4. A section to allow the entry of location names.

5. A PROMPT message area (at the base of the

screen). This area will be used almost exclusively for the display of prompt messages.

10.1 Function and keyboard keys.

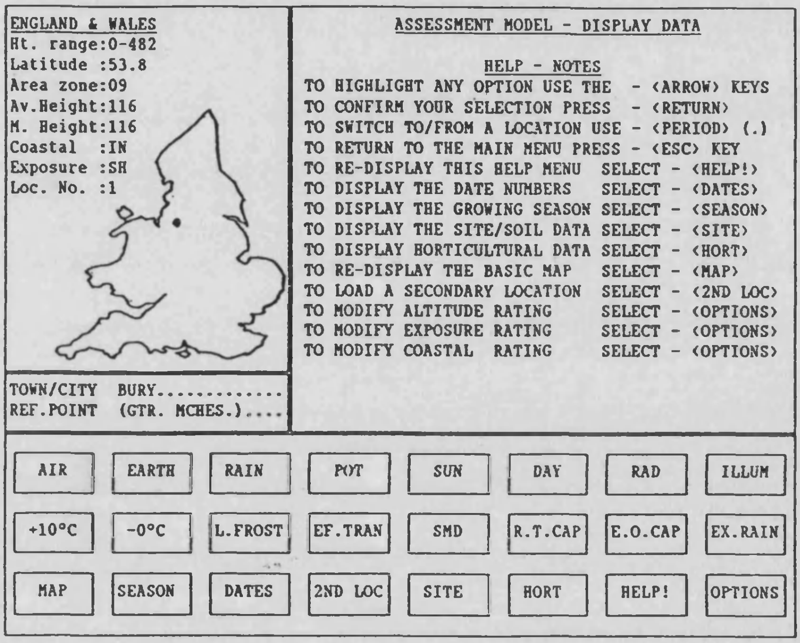
To the right of the TOWN\CITY caption you will see a STAR followed by a row of periods (full stops). At this point you can type in the name of your site. All the alpha-numeric keyboard keys are available for use. You simply type in the name and confirm your choice by pressing either <RETURN> or <ENTER>. To delete any spelling mistakes use the character deleting key, i.e. the key with the leftwards facing arrow - it is positioned directly above the <RETURN> key. The only other useful key at this moment will be the <ESC> key, which cancels everything and returns you to the Main Program Menu; remember this key it may get you out of a lot of trouble! The twelve function keys are not used within the assessment model, if you do press them either nothing will happen, or garbage will be printed on the screen.

10.2 Selecting a location.

As an example of entering a location name type the word BURY and press <RETURN>. If you make a spelling mistake use the character deletion key; if you decide to terminate the program press <ESC>. As you type you will notice that the town name is automatically converted into UPPER CASE, i.e.

capital letters. This is done as a method of standardising data entry, although in certain parts of the program you will be allowed to use both UPPER and LOWER case letters. Having typed the town name BURY and pressed <RETURN>, the computer will locate data from the hard disc and display it on the screen (Fig. 4).

Fig. 4. Displaying Town\City information.



You will find that if your spelling was correct and the location was pre-recorded the site related data will be displayed almost instantly. However, if spelt incorrectly or no location is entered the program will prompt you with an "ERROR MESSAGE" and allow you to try again. If the location was not found and you want to enter data relating to it return to the Main Program Menu (press <ESC>) and enter the location information via the Data Modification Program.

10.3 Displaying basic map and site related data.

The initial information relating to Bury will be displayed in two areas of the screen. Firstly, the Town\Location name is re-displayed directly below the map, and a black rectangle will be placed on the map. If a reference point has been pre-recorded it will be printed beneath the Town name. The reference point is useful as an "aide Memoire", when you wish to store information on a specific site within a town or city. The second set of information is displayed within the map area; it consists of the following :

A. Ht. **range.** The height range in metres highlights the lowest and highest points of the Reference Area Zone. In the case of the zone relating to BURY the range is from sea level (0 altitude) to 482 metres above sea level.

B. **Latitude.** The latitude displays information on the mean latitude of the Reference Area Zone; in this case 53.8 degrees north. It does not display the exact latitude of the selected location.

C. **Area zone.** The area zone is the Climatic Reference Area in which the location, i.e. Bury, is found (see appendix A). The height range, latitude and average height all relate to this zone.

D. Av. **height**. The average height is the mean altitude of the Reference Area Zone, i.e. 116 metres above sea level. It does not correspond to the exact height of the selected location.

E. **M.height**. The modified height is originally set to equal the average height of the zone, i.e. 116 metres above sea level. You can modify this number to equal the exact height of your site.

F. **Coastal**. The coastal rating is never pre-programmed, and is always initially set to equal inland (IN). You can modify this whenever required to indicate coastal sites.

G. **Exposure**. The site exposure rating is pre-set using data extracted from the Soil Survey of England and Wales Microclimatic Maps. In the case of Bury the symbol -SH- indicates that the site is sheltered. You can modify this to any one of 4 exposure ratings, these are as follows :

1. Very sheltered sites.
2. Sheltered sites.
3. Exposed sites.
4. Very exposed sites.

H. Loc. No. The location number corresponds to individual locations. When only 1 location has been selected the Location number is 1. When two locations have been selected the location number is either 1 or 2. You can toggle from the first to second location by pressing the <PERIOD> key (see below).

10.3.1 Displaying generalised climate related information.

To the right of the map you will see an area of the screen entitled "ASSESSMENT MODEL - DISPLAY DATA". This area is used to display a wide range of information, it is known as the "Main Data Display Area". When a location is initially selected the display prints a list of "HELP NOTES" which outline all of the available keys and selection options. This list can always be re-displayed by selecting the <HELP!> box in the prompt area (see 10.3.2).

10.3.2 Initial Prompt Area display.

Having selected a location the PROMPT area will display three rows of eight rectangular "Selection Menu Boxes" containing various words (Fig. 4). Each box allows you to display or modify data relating to specific topics. Initially, the top left hand box, entitled "AIR" will be "HIGHLIGHTED" in light blue. To move from one box to the next use the 4 <ARROW> keys positioned between the main "QWERTY" keyboard and the calculator style pad. To select one of the options simply highlight its box and confirm your choice by pressing either <RETURN> or <ENTER>.

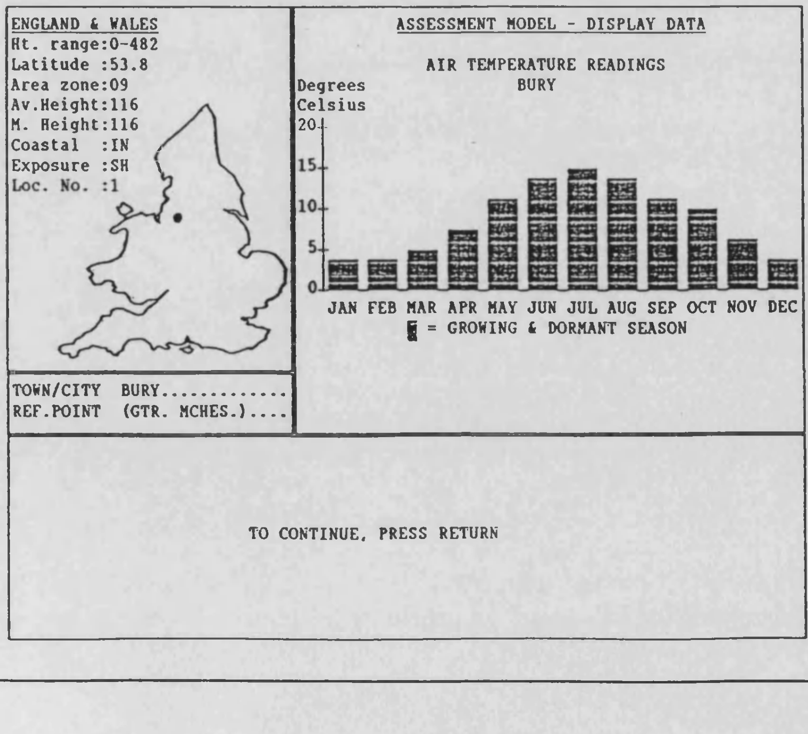
10.4 Displaying mean monthly climate related data.

The top row of eight boxes in the PROMPT area (Fig. 4) all display mean monthly data relating to the following specific climatic topics :

1. Air temperatures.
2. Earth temperatures.
3. Annual rainfall.
4. Potential transpiration.
5. Sunlight.
6. Daylength.
7. Solar radiation.
8. Illumination.

Selection of these topics consists of moving the highlight (the light blue rectangle) to the required box followed by pressing <RETURN>.

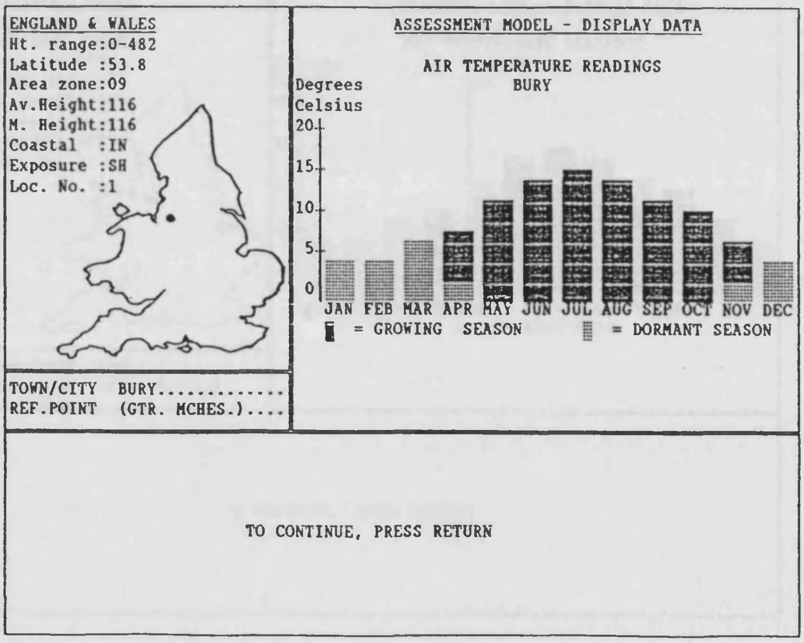
Fig. 5. Display of monthly mean climatic data.



If you select the "AIR" box, in the top left hand corner, the screen will display the data as shown in Fig. 5.

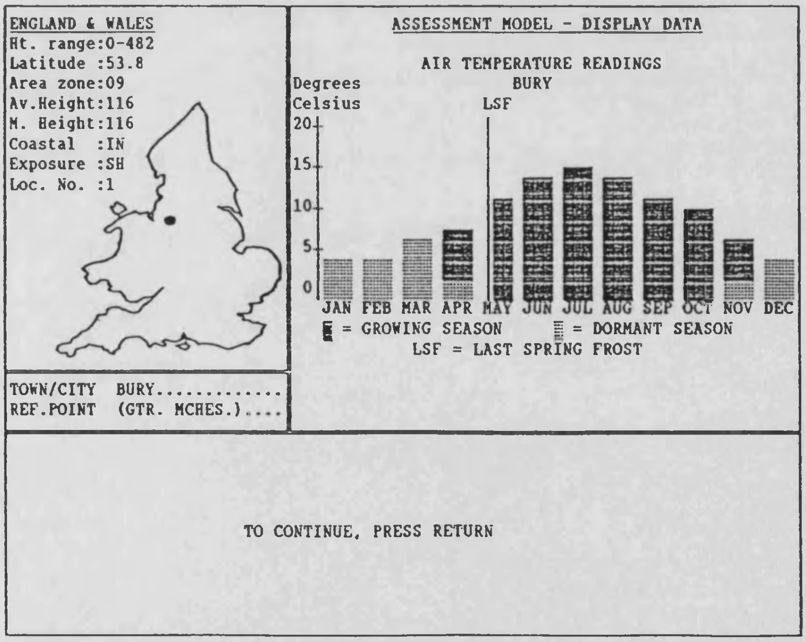
The data for mean air temperatures for the climatic zone will initially be displayed, in histogram form, for each of the twelve months of the year. The program will hold the display for your perusal and the PROMPT message will tell you to press <RETURN> whenever you wish to continue. The next time you press <RETURN> a new screen of Mean Air Temperature readings will be displayed (Fig. 6), only this time the information with be broken down into both the growing and dormant seasons.

Fig. 6. Display of growing and dormant season data.



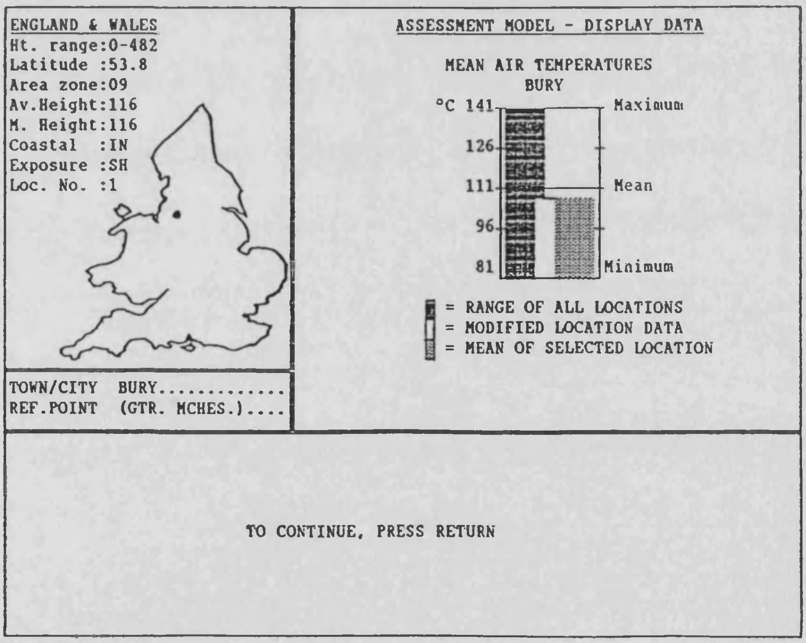
After printing the growing\dormant season data the program will halt once more, and display a PROMPT message asking you to press <RETURN> when you are ready to continue. The next time <RETURN> is pressed the same data will be re-displayed (Fig. 7), but this time a vertical line will be superimposed indicating when the Last Spring Frost for the zone is expected to occur. Remember, this is only an approximation for the zone as a whole. It does not change, even when you make modifications to the climate. For a more detailed display of Last Spring Frost you should select the "L.FROST" box from the Selection Menu Boxes (see Fig. 4).

Fig. 7. Displaying the last expected spring frost data.



The final screen (Fig. 8) relating to the Mean Air Temperature data provides another graphical display in histogram form. This time, however, the data for the selected location are printed in relationship to the mean maximum and minimum range of Air Temperatures for all 70 zones. In addition, it also displays information corresponding to the modified climate for the location. As you change the various climate "CORRECTION FACTORS" this display will be automatically recalculated to show the projected climate modification. Having displayed the histogram the program will print a prompt message asking you to press <RETURN> when you are ready to continue. When the <RETURN> key is pressed the prompt line will clear and the Selection Menu Boxes will be re-displayed (Fig. 9).

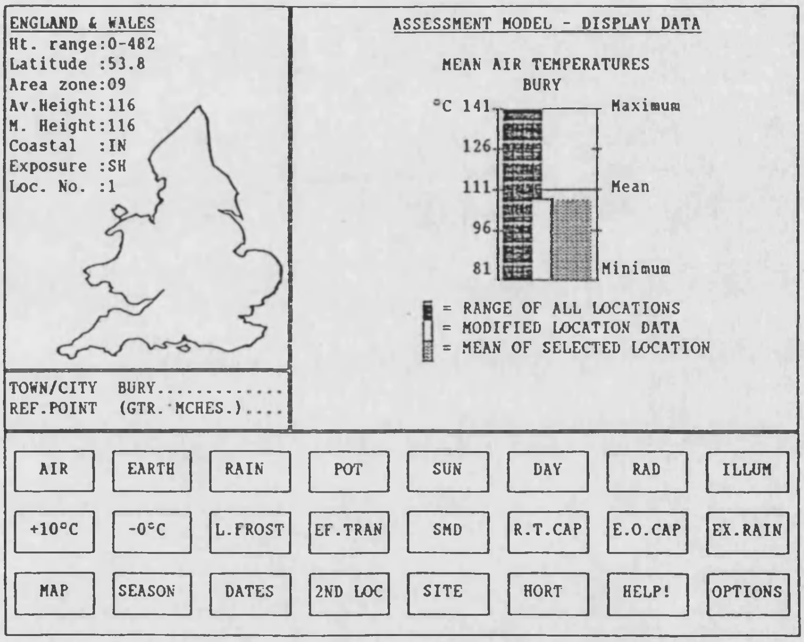
Fig. 8. Display of mean maximum and minimum air temperature data.



Seven of the top row of eight Selection Menu boxes, i.e. AIR, EARTH, RAIN, POT, SUN, DAY and ILLUM, display data in the same way as in figures 5 - 9.

The "RAD" box, however, is a slight exception. In this case an extra display is included to show the Solar Radiation data in the form of Watts/m². The original Meteorological Office data of Solar Radiation was produced in Milliwatt hours/cm², which is an inconvenient parameter rarely used in insolation studies. Watts/m² is a measure of intensity derived from the power units Milliwatt hours/cm², its use does introduce slight inaccuracies, but these are small and in most cases can be ignored.

Fig. 9. Final display for Air Temperature data.



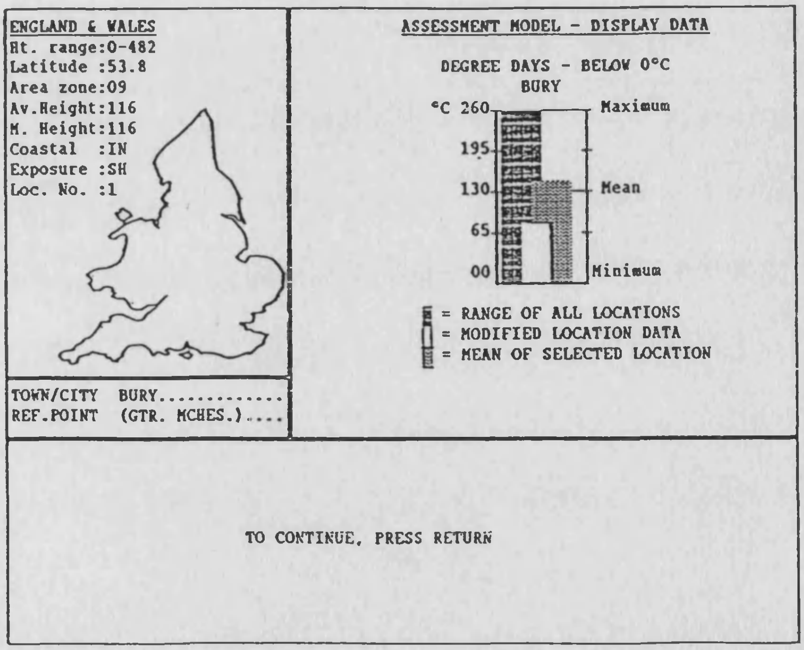
10.5 Displays relating to maximum/minimum zonal data.

The second row of Selection Menu boxes (see Fig. 4 & 9) allow the display of data relating to the following :

1. Accumulated temperatures above 10°C.
2. Accumulated temperatures below 0°C.
3. The projected last spring frost.
4. The effective transpiration.
5. Soil moisture deficits.
6. The return of the soil to field capacity.
7. The end of field capacity.
8. Excess winter rain.

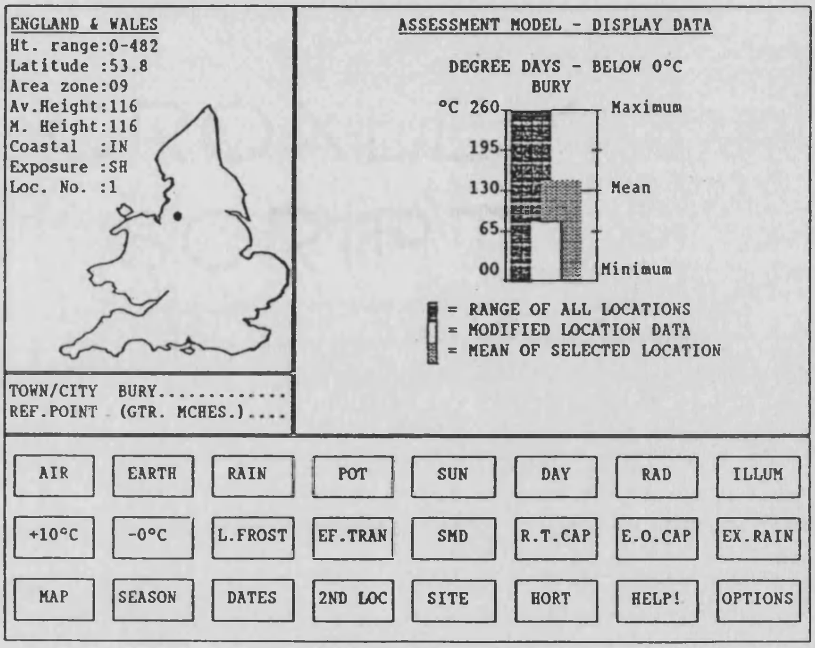
The data associated with the above 8 topics are all printed in direct relationship to the mean maximum and minimum range of the 70 climatic zones.

Fig. 10. Maximum & minimum Accumulated temperatures below 0°C.



In addition, the program also displays information corresponding to the modified climate for the location (see Fig. 10). As you change the various climate correction factors this display will be automatically recalculated to show the projected climate modification. Having displayed the histogram the program will print a prompt message asking you to press <RETURN> when you are ready to continue. When the <RETURN> key is pressed the prompt line will clear and the Selection Menu Boxes will be re-displayed (Fig. 11).

Fig. 11. Final display of accumulated day degrees below 0°C.



You will notice that the modified location data associated with Accumulated day - degrees below 0°C (Figs 10 & 11) does not correspond to the mean of the selected location, i.e. the mean for Bury. The reason for this is that before displaying anything the program checks through the resident climatic and site data, for example, the exposure and coastal proximity figures, and then calculates the modified climatic data accordingly. You should note that by changing modification factors, such as altitude, you will automatically affect a wide range of climatic data.

10.6 Displaying the growing season data.

The program will allow you to view information, in the form of "Pie" charts, on the estimated length of the Growing/Dormant season for any selected location. The calculations have been produced using data collated for growing season length of grassland, and are, therefore, not wholly suited for use on ornamental taxa. It has been found, however, that they do provide a good broad indication of the generalised growing season.

To display this option move the highlight to the "SEASON" Selection Box and press <RETURN>. Once the key is pressed the program will delete whatever is in the map area and display the growing season information (Fig. 12).

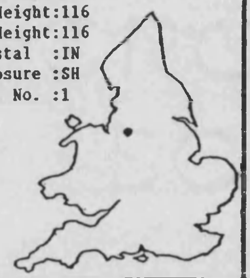
Note that whatever is printed in the other areas of the screen is unaffected, and that having displayed the information the program returns control to the prompt area and waits for you to press <RETURN> once more.

10.7 Displaying Dates information.

Some of the site climatic information is displayed the hard disc and display it on the screen (Fig. 16). If, for any reason, the town/city is not located the program will inform you and allow you to make another selection.

Fig. 15. Entering a second location.

ENGLAND & WALES
Ht. range:0-482
Latitude :53.8
Area zone:09
Av.Height:116
M. Height:116
Coastal :IN
Exposure :SH
Loc. No. :1



ASSESSMENT MODEL - DISPLAY DATA

HELP - NOTES

TO HIGHLIGHT ANY OPTION USE THE	-	<ARROW> KEYS
TO CONFIRM YOUR SELECTION PRESS	-	<RETURN>
TO SWITCH TO/FROM A LOCATION USE	-	<PERIOD> (.)
TO RETURN TO THE MAIN MENU PRESS	-	<ESC> KEY
TO RE-DISPLAY THIS HELP MENU	SELECT -	<HELP!>
TO DISPLAY THE DATE NUMBERS	SELECT -	<DATES>
TO DISPLAY THE GROWING SEASON	SELECT -	<SEASON>
TO DISPLAY THE SITE/SOIL DATA	SELECT -	<SITE>
TO DISPLAY HORTICULTURAL DATA	SELECT -	<HORT>
TO RE-DISPLAY THE BASIC MAP	SELECT -	<MAP>
TO LOAD A SECONDARY LOCATION	SELECT -	<2ND LOC>
TO MODIFY ALTITUDE RATING	SELECT -	<OPTIONS>
TO MODIFY EXPOSURE RATING	SELECT -	<OPTIONS>
TO MODIFY COASTAL RATING	SELECT -	<OPTIONS>

TOWN/CITY BURY............
REF.POINT (GTR. MCHES.)....

SECOND LOCATION : TOWN/CITY BATH...............
REF.POINT ....

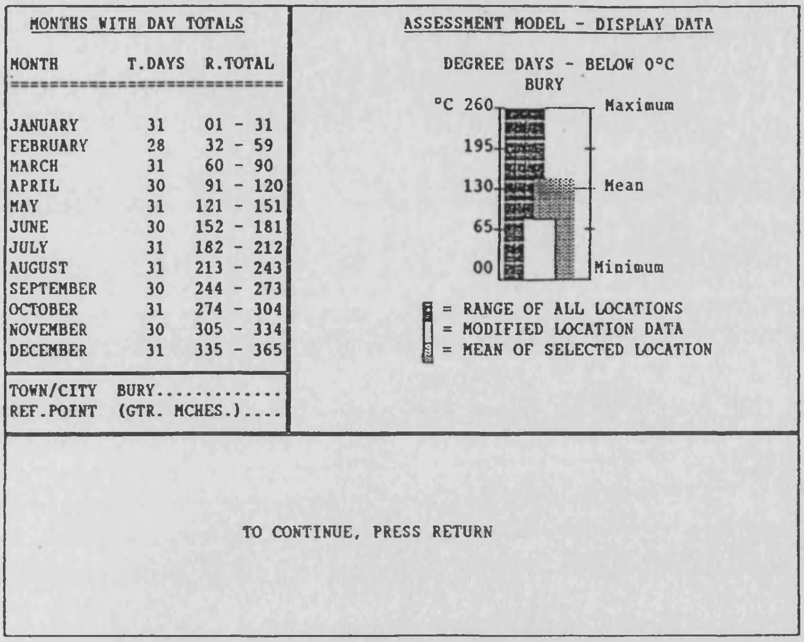
TYPE IN THE <LOCATION> NAME, THEN PRESS RETURN

Having retrieved the second location data the program will redisplay the map and flash the black box to remind you where your first location is. It will then flash a yellow box to indicate the relative position of your second location, and continue by printing the climatic data for Bath in the map area (Fig. 16). Note that the location number is now 2.

To "toggle" between the first and second locations simply press the period key (full stop), whenever the Selection Menu Box options are displayed.

(Fig. 13). Note that whatever is printed in the other areas of the screen is unaffected, and that having displayed the information the program returns control to the prompt area and waits for you to press <RETURN> once more.

Fig. 13. Displaying the Dates information.



MONTHS WITH DAY TOTALS

MONTH	T.DAYS	R.TOTAL
JANUARY	31	01 - 31
FEBRUARY	28	32 - 59
MARCH	31	60 - 90
APRIL	30	91 - 120
MAY	31	121 - 151
JUNE	30	152 - 181
JULY	31	182 - 212
AUGUST	31	213 - 243
SEPTEMBER	30	244 - 273
OCTOBER	31	274 - 304
NOVEMBER	30	305 - 334
DECEMBER	31	335 - 365

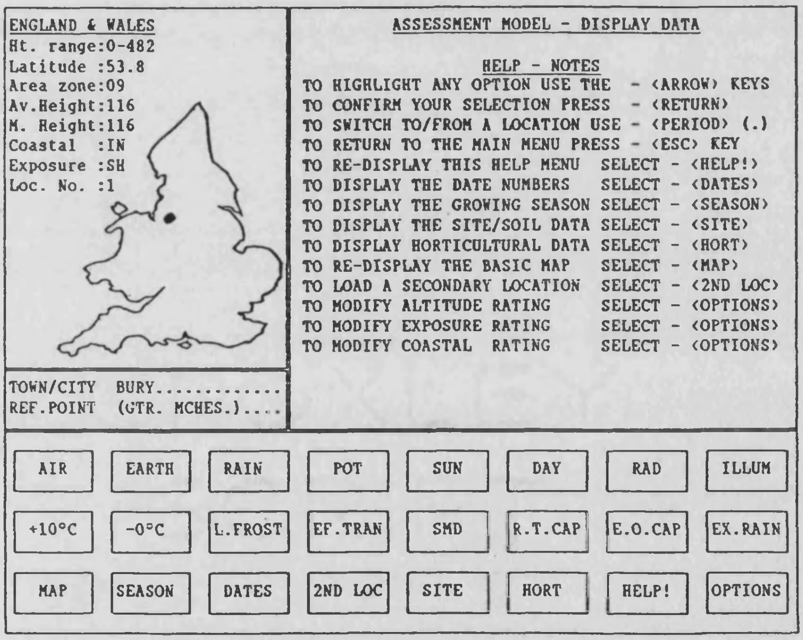
TOWN/CITY BURY.............
REF.POINT (GTR. MCHES.)....

10.8 Re-displaying information.

We have now covered all 16 climatic criteria and outlined the various screen displays which are used to show the information. What we have not done is to describe how to modify the data and re-display all parts of the screen. The data modification will be described later, but for now it will be advantageous to be able to know how to display selected information as and when you require it.

When the Selection Menu Boxes are displayed in the prompt area (see Fig. 14), you can re-display a range of information. For example, using the 4 arrow keys, move the light blue highlight to the "HELP!" box and press <RETURN>. As soon as the key is pressed the program will delete whatever is in the main display area and re-print the HELP notes. Notice that on completion the highlight automatically returns to the "AIR" box. You can do a similar thing with the map of England and Wales.

Fig. 14. Display highlighting the Selection Menu Boxes.



To re-display the map move the light blue highlight down to the "MAP" box and press <RETURN>. As the key is pressed the program will delete whatever is displayed in the map area and re-print the map and corresponding zonal information. Once the map is displayed a small black square will flash to indicate the relative position of the selected location.

10.9 Selecting a second location.

It is sometimes useful to be able to compare two locations together, so as to gain an impression of how close their climate and growing conditions are. The assessment model allows you to specify a second location at any time when the Selection Menu Boxes are displayed (Fig. 14).

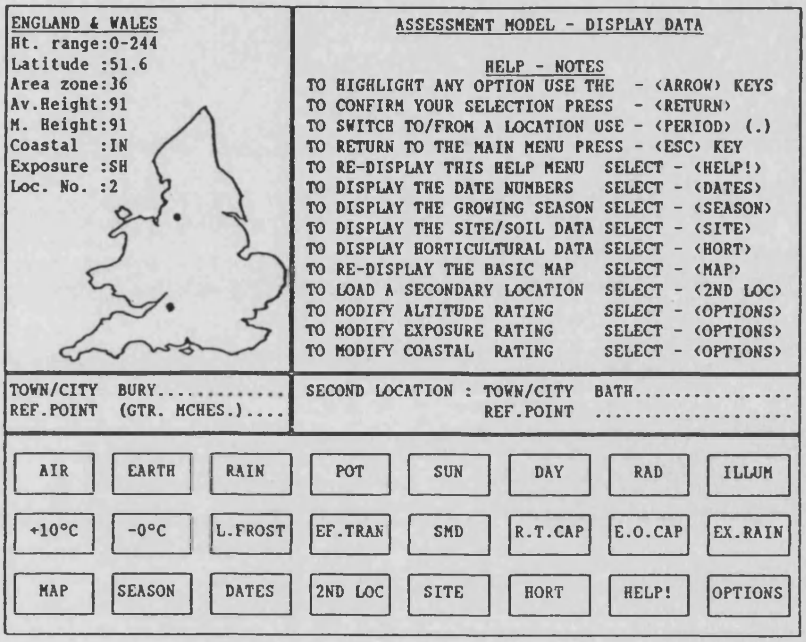
Once loaded, you can "toggle" between the first and second locations, and modify the climatic and site related factors for both. You can even discard your selected second location and replace it with another one.

To select a second location move the light blue highlight to the "2ND LOC" box in the prompt display area (Fig. 14) and confirm your selection by pressing <RETURN>. The information printed in the Main Display Area will remain intact, but the map will be re-displayed, and a new prompt will ask you to enter your second location choice (Fig. 15). Type in the city name BATH and press <RETURN>. Remember if you make a spelling mistake you can use the delete character key to make modifications.

After typing the second location name, and having pressed <RETURN> the program will locate the data on

If you wish to discard your second location and choose another, all you need do is select the "2ND LOC" option once more and enter the new name. You will find that the old location remains displayed on the map as an aide memoire until you redisplay the whole map.

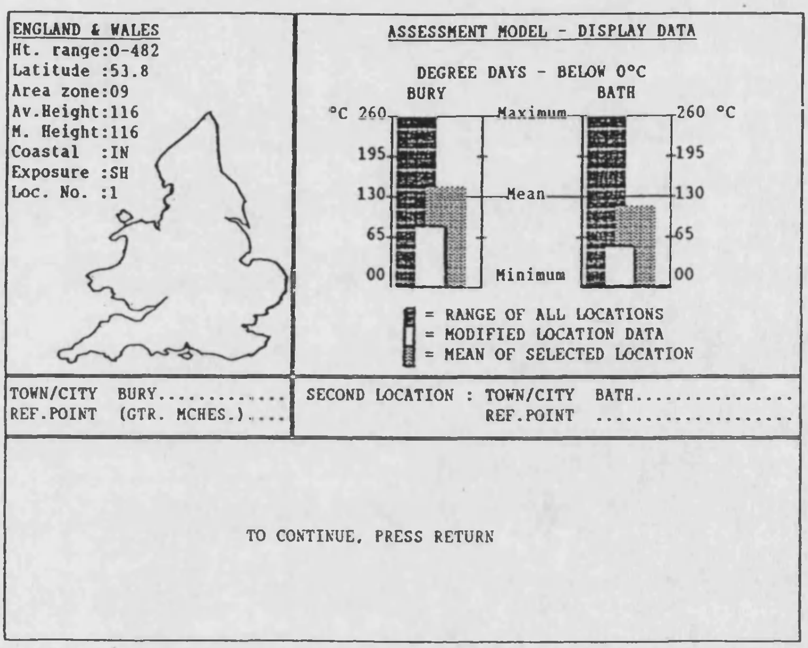
Fig. 16. Displaying second location data.



When more than one town/city has been specified the program must know which is the active location. It does this by checking the location number, i.e. the "Loc. No." in the map display area. If the location number is 1 the program will display data relating to the first location, if the number is 2 the second location will be active and data for that town will be displayed.

One of the features of the assessment program is that you can compare the two locations together and modify the climatic criteria for each. When viewing data on a specific topic for two locations the program will display the information side by side (Fig. 17) so that a direct comparison can be obtained.

Fig. 17. An example of a double location display.

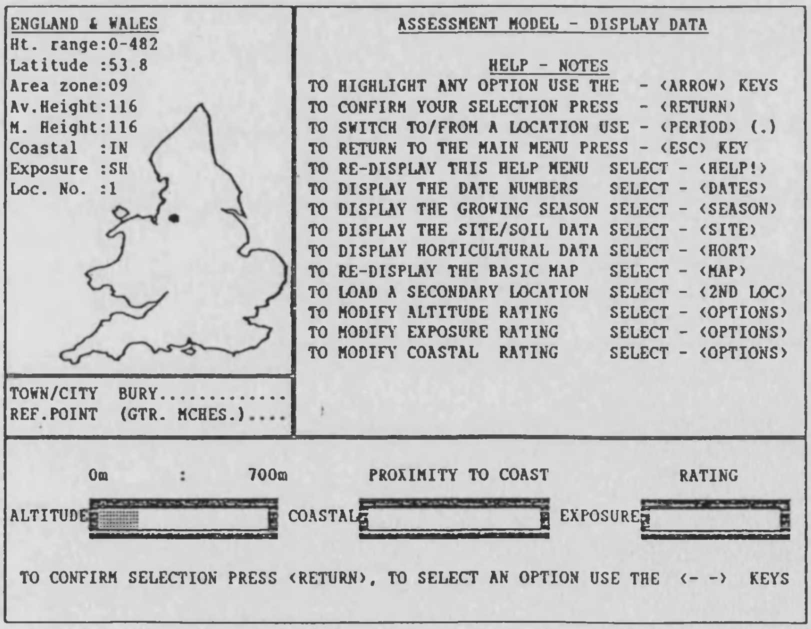


10.10 Making modifications to the climate related data.

It was mentioned in section 10.5 above, i.e. displays relating to maximum and minimum zonal data, that it is possible to make modifications to the climatic ratings. This feature of the program allows you to make minor adjustments, so that the climate of your selected locations is more accurate than mean figures for the overall climatic zones. To make adjustments of this kind you must first select the "OPTIONS" box in the bottom right hand corner of the prompt area, and then confirm your selection by pressing <RETURN>. If you have selected two locations it is important for you to remember to toggle on to the correct one before entering the "OPTIONS" section, otherwise you will modify the wrong location data.

When you enter the climate modification section you will find that the map and data relating to the current location will be re-displayed, but the Main Display Area will be left unchanged (Fig. 18).

Fig. 18. Modifying climatic data.



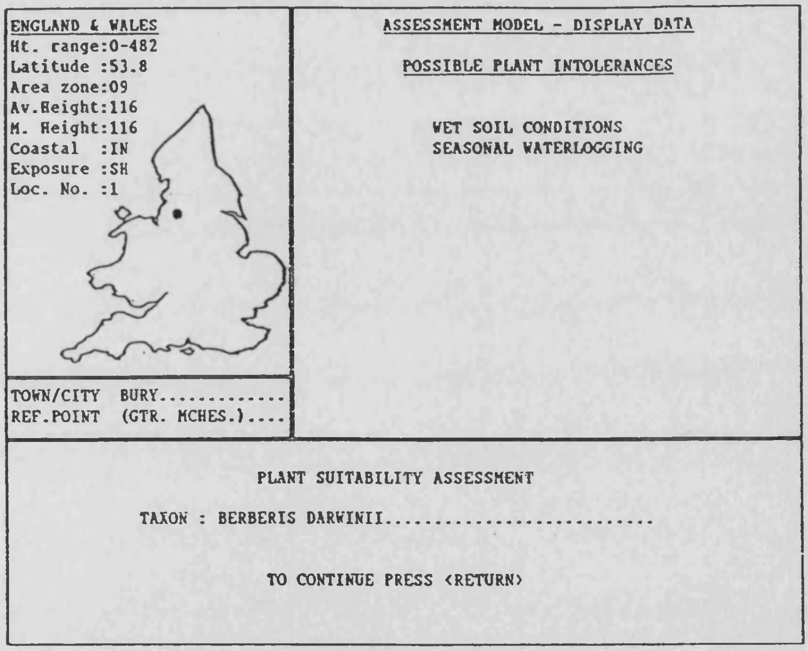
The prompt area at the bottom of the screen will show the availability of the following 3 modification options :

1. Altitude adjustment.
2. Coastal proximity adjustment.
3. Exposure rating.

It is important to remember that once modifications are made they will remain set until you either re-modify them, or leave the program.

Before any adjustments are made the program will only show the current altitude rating; the coastal and exposure ratings will be left blank (Fig. 18).

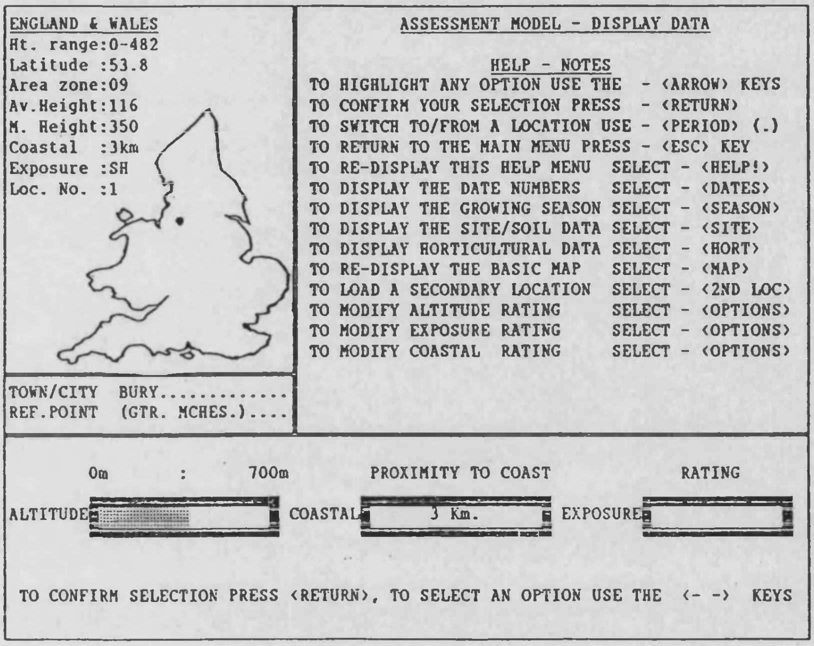
Fig. 30. Displaying the plant intolerances.



10.10.1 Modifying the altitude.

To raise the altitude of the site hold down the RIGHT facing ARROW key. As you do so two things will happen. Firstly, the altitude figure in the map area will start to increase, and secondly, the DISPLAY BLOCK in the prompt area will start to get larger. When the altitude reaches the correct height, e.g. 350m, (Fig. 19) release the key, and confirm your selection by pressing <RETURN>. To lower the altitude simply follow the above method only this time hold down the LEFT facing ARROW key.

Fig. 20. Modifying coastal proximity data.



10.10.2 Modifying the coastal rating.

Having selected the altitude of your choice the program will move control to the Coastal proximity rating. This is initially set to INLAND, but it can be modified by using the LEFT and RIGHT facing ARROW keys. The left arrow key will select an INLAND site, whereas the right arrow key will select a site within 3km of the coast (Fig. 20). You should note that as you hold down either of the arrow keys the shorthand coastal rating in the map data area, i.e. "IN" for INLAND and "3km" for COASTAL PROXIMITY, will change to correspond with the selected rating.

10.10.3 Modifying the exposure rating.

Whenever a location is initially selected the assessment program will load data relating to its potential exposure. This rating is obtained from Microclimatic maps produced by the Soil Survey of England and Wales, and is used only as an initial guide. To modify the rating you use the LEFT and RIGHT arrow keys as you did previously with both altitude and coastal proximity. There are 4 exposure ratings, these are :

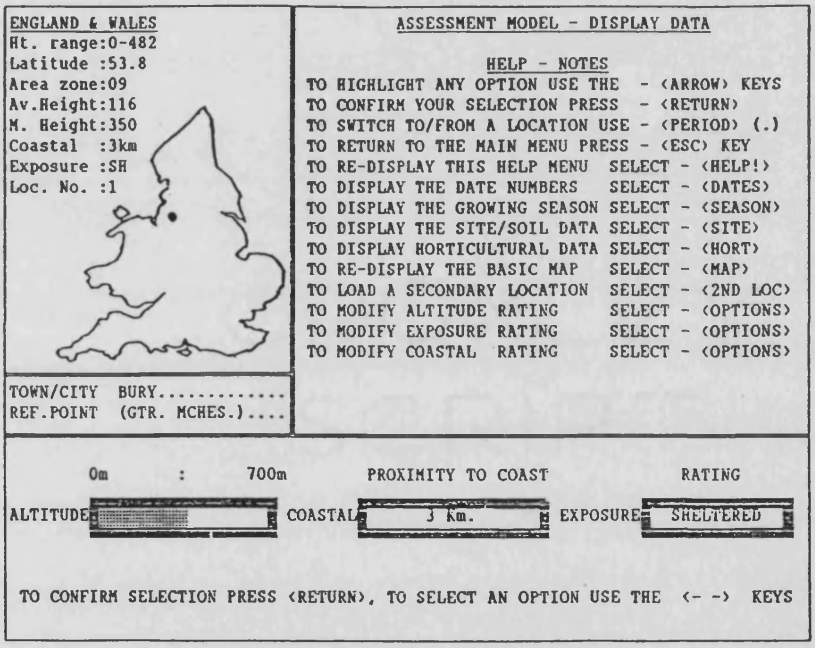
1. Very sheltered (VS).
2. Sheltered (SH).
3. Exposed (EX).
4. Very exposed (VX).

As you move through the options the shorthand exposure rating in the map data area will change to correspond with the current rating (Fig. 21), and the longhand description will be displayed in the prompt area.

10.11 Displaying soil and site related data.

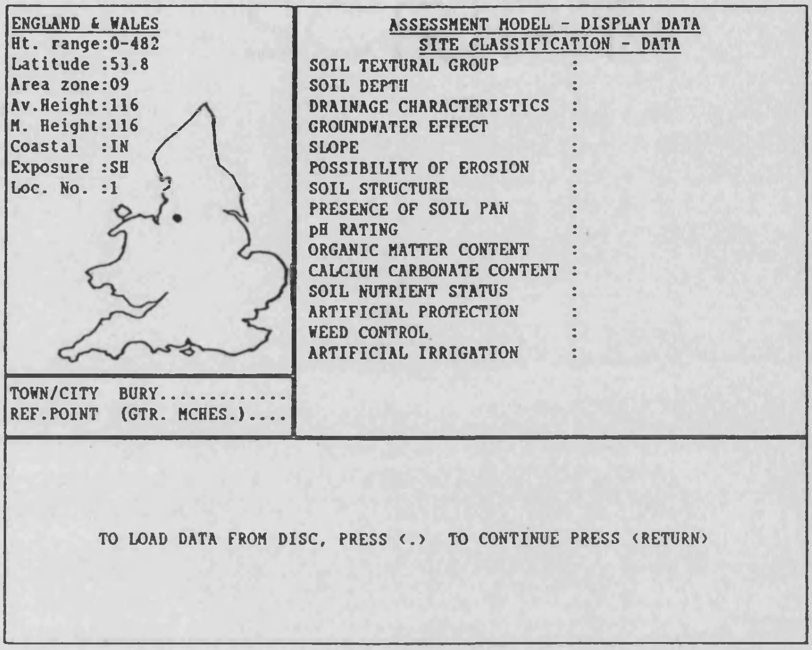
One of the most important features of any site used for growing ornamental landscape taxa is the condition of the soil. On many modern planting sites the use of heavy machinery in inclement conditions, plus inadequate site management, frequently leads to de-structured and de-natured soils. Having a good knowledge of how to maintain soils on landscape sites is a precursor to good plant establishment and subsequent growth. The assessment model allows you to view and modify information relating to a specific soil and site. Having set up the soil parameters the program will then evaluate the suitability of selected taxa for the conditions.

Fig. 21. Modifying exposure data.



To view or make adjustments to the soil and site parameter you must select the "SITE" option from the Selection Menu Boxes when displayed in the prompt area. You do this by moving the light blue highlight over the "SITE" box and confirming your choice by pressing <RETURN>. Once selected the screen will appear as in figure 22.

Fig. 22. Soil and Site related data.



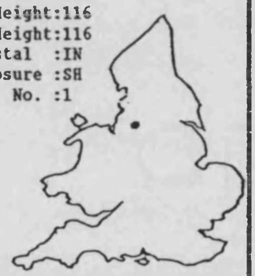
When you select "SITE" the program will ask if you wish to load site related data from disc, or continue by displaying data loaded at a previous visit. When you initially choose this option the program will load data from disc whether you press <RETURN> or the period (full stop). It is only on subsequent visits that you may choose to retain pre-loaded information.

After loading some soil/site data the program will print it in the main display area (Fig. 23) and you will be allowed to either accept it unaltered, or modify all or any part of it.

Some of the data which are initially loaded from disc are compiled by assessing the characteristics inherent to the nearest soil type for the area. This information is available from the Soil Survey of England and Wales in the form of 1:250,000 scale maps (see section 10.14). Unfortunately, the soils in many large towns and cities bear little, if any, resemblance to these maps. In many cases, even in rural areas, the soils have been modified so much that they should be described as "Man made".

Fig. 23. Displaying Soil and Site related data.

ENGLAND & WALES
Ht. range:0-482
Latitude :53.8
Area zone:09
Av.Height:116
M. Height:116
Coastal :IN
Exposure :SH
Loc. No. :1



TOWN/CITY BURY.............
REF.POINT (GTR. MCHES.)....

ASSESSMENT MODEL - DISPLAY DATA
SITE CLASSIFICATION - DATA

SOIL TEXTURAL GROUP	: LOAMY
SOIL DEPTH	: DEEP SOIL
DRAINAGE CHARACTERISTICS	: WELL DRAINED SOILS
GROUNDWATER EFFECT	: SEASONALLY WATERLOGGED
SLOPE	: FLAT LAND
POSSIBILITY OF EROSION	: POSS. PROBLEM
SOIL STRUCTURE	: WELL STRUCTURED
PRESENCE OF SOIL PAN	: PANS PRESENT
pH RATING	: SLIGHTLY ACID
ORGANIC MATTER CONTENT	: LOW O. MATTER
CALCIUM CARBONATE CONTENT	: NON-CALCAREOUS
SOIL NUTRIENT STATUS	: INDEX 0
ARTIFICIAL PROTECTION	: NO PROTECTION GIVEN
WEED CONTROL	: NO WEED CONTROL GIVEN
ARTIFICIAL IRRIGATION	: NO IRRIGATION GIVEN

TO CONTINUE PRESS <RETURN>, MODIFY DATA PRESS <.>

TO DISPLAY THE SOIL SURVEY INFORMATION PRESS </>

You should note that the Soil Survey of England and Wales data can refer to similar soils spread over a wide area and that parts of the site descriptions, for example, the possibility of seasonal waterlogging, may only relate to a small portion of the overall soil type. This means that a generalised description may indicate the presence of an adverse feature, whereas in fact no such problem exists. The best way to find out the main characteristics of any site is to actually go and carry out a detailed survey.

10.12 Soil and site data modification.

Having displayed the soil/site related data the program will print 2 prompt messages, the first of which allows you to either continue, or modify some of the information, and the second allows the display of the Soil Survey of England and Wales data.

By pressing the period key at this prompt message the program will allow the selection of individual criteria. As each type of data is displayed, starting with the textural class, you will be able to "SCROLL" through the various options selecting the items which meet your requirements, and confirming your choice each time by pressing <RETURN>. The complete list of options is listed below :

<u>Textural class</u> : Loamy
Clayey
Silty

		Sandy
		Peaty
		Rubble, spoil & Waste
<u>Soil depth</u>	:	Deep soil
		Shallow soil
<u>Drainage characteristics</u>	:	Well drained soils
		Slowly permeable
<u>Groundwater effect</u>	:	No groundwater problem
		Water-logged conditions
		Seasonally water-logged
<u>Slope</u>	:	Flat land
		Steep slopes
<u>Possibility of erosion</u>	:	No problem
		Poss. problem
<u>Soil structure</u>	:	Well structured
		poor structure
<u>Presence of soil pan</u>	:	None present
		Pans present
<u>pH rating</u>	:	Slightly acid
		High pH
		Low pH
<u>Organic matter content</u>	:	Low O. matter

Moderate O. matter

FYM applied

<u>Calcium carbonate content</u> : Non-calcareous

Calcareous

<u>Soil nutrient status</u> : Index 0

Index 1

Index 2

Index 3+

<u>Artificial protection</u> : No protection given

Plant shelters used.

<u>Weed control</u> : No weed control given

Control until mid-June

Control until mid-July

Total weed control

<u>Artificial irrigation</u> : No irrigation given

25mm at 75mm SMD

When you have finished selecting criteria the program will ask if your selections are correct. If not, you will be given the opportunity to re-select them, otherwise the program will allow you to display a series of NOTES AND RECOMMENDATIONS highlighting possible site related problems (Fig. 24).

Fig. 24 Displaying Notes relating to altitude.

GROWTH MODEL - NOTES & RECOMMENDATIONS

LOCATION : BURY
ALTITUDE IS OVER 120m

As altitude increases climatic changes occur which can adversely affect the growth and establishment of plants. The most important of these changes are a lowering of air and earth temperatures, higher rainfall, a shortening of the growing season and a potential increase in the frequency and severity of ground and air frosts. Taxa which are not Frost Hardy may be severely damaged, or even killed at relatively low altitudes, especially when grown in exposed situations, or in 'frost pockets', where the movement of cold air is restricted by either a natural or man made barrier.

TO CONTINUE PRESS THE <RETURN> KEY

10.13 Displaying the Notes and Recommendations.

When you have identified the climatic and soil characteristics the program will make a number of detailed calculations leading to the production of a general appraisal of the planting site. Having made an assessment it will then select and allow you to display a number of NOTES and RECOMMENDATIONS relating to either possible planting site problems, e.g. increasing altitude (Fig. 24), or methods of improving the establishment rate and subsequent growth of taxa on the site, for example fertiliser applications (Fig. 25). There are over 50 possible notes and recommendations, although the program will usually only display a small proportion of them for each specific site.

Fig. 25 Displaying Fertiliser Recommendations.

GROWTH MODEL - NOTES & RECOMMENDATIONS

LOCATION : BURY
SOIL NUTRIENT STATUS

Nitrogen Applications (Index 0)

Ist Year	kg/ha N
Slow growing species	50
Faster growing species	100

2nd & Subsequent Years	kg/ha N
Slow growing species	0- 50
Faster growing species	50-150

Newly planted stock is sensitive to excessive rates of soluble fertiliser. For all species do not apply more than 50kg/ha of nitrogen before planting, the remainder being applied as a topdressing once the plants are established.

TO CONTINUE PRESS THE <RETURN> KEY

Fig. 26 Displaying Soil Survey of England & Wales data.

GROWTH MODEL - DISPLAY SOIL DATA

SOIL SURVEY OF ENGLAND & WALES

Bury
FILE NO. : 60

MAP/SUBGROUP	: 541g
SOIL ASSOCIATION	: Rivington 2
SOIL MAP SYMBOL	: Typical Brown Earths
SOIL MAP SYMBOL NUMBER	: 541
ANC. SUBGROUPS & SERIES	: 167/168 Withnell 542 Heapey
GEOLOGY	: Palaeozoic sandstone and shale
SOIL/SITE CHARACTERISTICS	: Well drained coarse loamy soils over rock. Some fine loamy soils with slowly permeable subsoils and slight seasonal waterlogging.
CROPPING AND LAND USE	: Stock rearing and dairying; some arable land and coniferous and deciduous woodland.
AREA (Sq. Kilometres)	: 933 (.61)

TO CANCEL PRESS <RETURN>, TO SCROLL USE <- -> KEYS, FOR OPTION PRESS <.>

10.14 Displaying the Soil Survey of England and Wales data.

After selecting or modifying the soil/site related data (section 10.11 and Fig. 23) the program will give you the option to display the information as supplied by the Soil Survey of England and Wales (Fig. 26). You will notice that a number of headings are printed on the left hand side of the screen, these are as follows :

1. **File number** - the position in the assessment program data file where the specific entry is stored. The number will be in the range 1-297. Entry number 297 is classed as unsurveyed, mainly urban and industrial areas. This should be the major group for locations within most towns and cities, but unfortunately, it gives little, if any, detailed information. To help alleviate this problem the assessment program holds data relating to the nearest classified soil type to the selected site.

2. **Map/subgroups** - The map identification and subgroup symbols. These are used to identify individual soil types on the 1:250,000 Soil Survey maps.

3. **Soil Association** - The name given to the type of soil.

4. **Soil map symbol** - In the Soil Survey system each soil type is given a number corresponding to a

generalised soil description.

5. **Soil map symbol number** - The number used to identify the group / subgroup and generalised description in which the soil is placed.

6. **Ancillary sub-groups and series** - Groups with similar characteristics to the selected soil type.

7. **Geology** - The basic geology of how the soil was formed and the materials used in its formation.

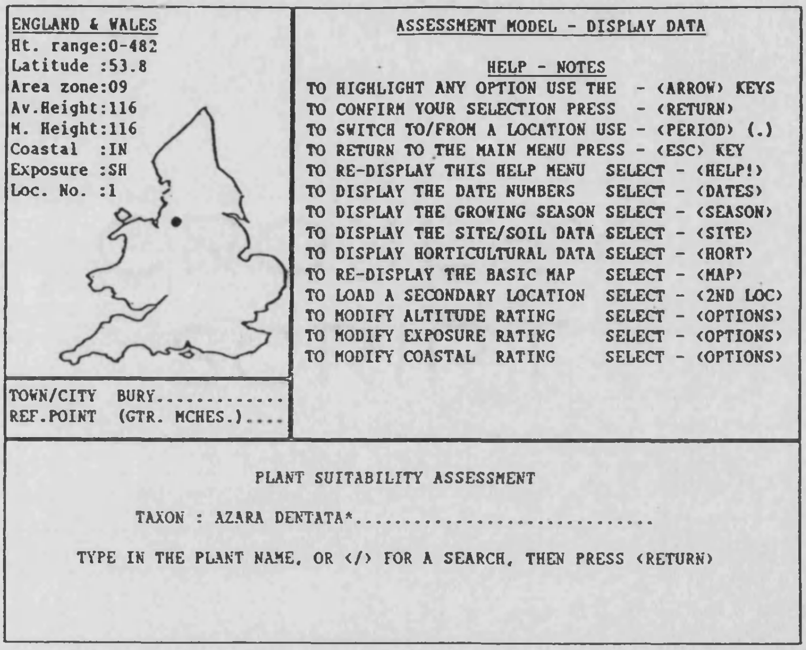
8. **Soil/site characteristics** - A general description of the soil and related site, giving details of drainage characteristics, potential risk of erosion, the slope of the land and the soil textural groups.

9. **Cropping/land use** - The crops and land uses which the soil is most often used for.

10. **Area** - The total area in square kilometres of the soil type in the country, and in brackets, the percentage of the whole country, i.e. all soil types.

Once the initial data have been displayed you will be given 3 options. By pressing <RETURN> the program will return control to the Selection Box Menu. To individually SCROLL through the soil entries use the arrow keys; for higher numbered entries press the RIGHT pointing arrow key, and for lower numbered entries press the LEFT pointing arrow key. To view an entry which has a considerably higher of lower file number than the currently displayed screen simply press the PERIOD key, type the entry number, and confirm your choice by pressing <RETURN>. The program will then locate your entry and print the information on the screen.

Fig. 27 Checking the hardiness rating of a plant.

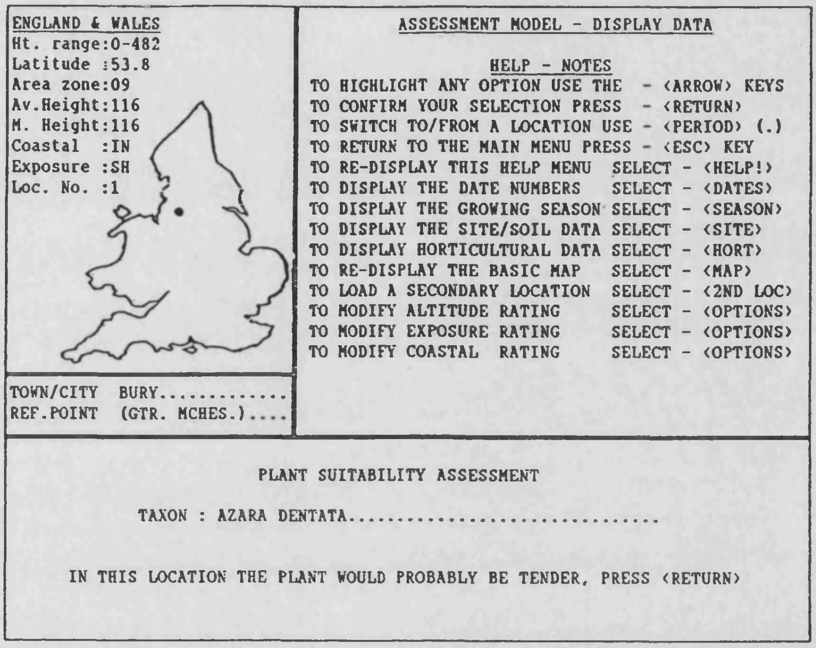


10.15 Plant suitability.

The climatic and site criteria allow you to specify the type of weather and growing conditions exhibited by your selected location. The taxon related options then allow you to match your potential planting material to the site. You choose this option by highlighting the "HORT" selection box (Fig. 4), and you then confirm your choice by pressing <RETURN>.

Having selected this option the prompt area of the screen will clear and you will be asked to enter the name of the plant which you wish to assess (Fig. 27). You simply type in the name, and confirm that it is correct by pressing <RETURN>.

Fig. 28 Displaying the hardiness rating of a selected plant.



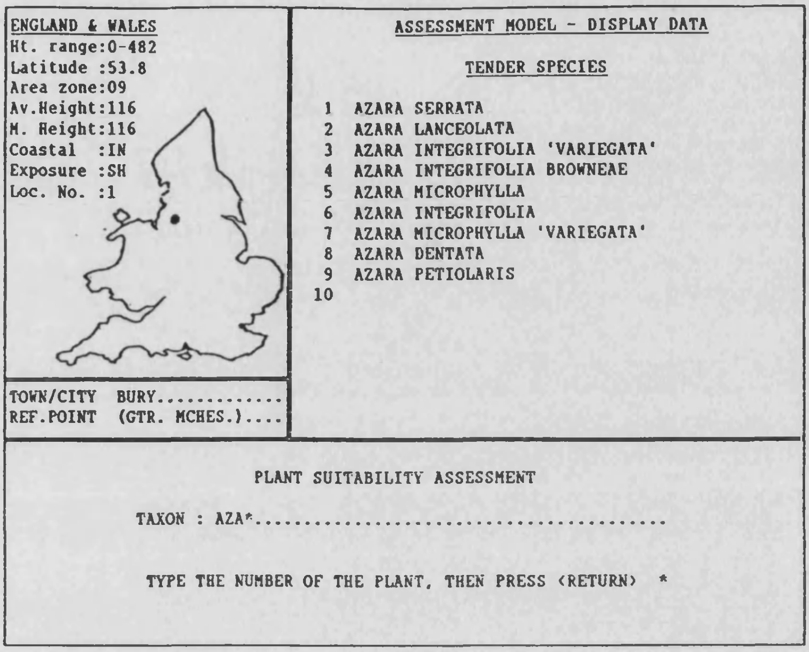
The program will proceed by checking the site altitude, exposure, coastal proximity and the amount of potential Accumulated Day-Degrees below 0°C. If these are within an acceptable range you will be informed that the plant will probably be hardy at your specified location. If the climatic conditions are unacceptable, however, the program will search a pre-compiled list of potentially tender plants. If found you will be informed that the plant will probably be tender at your site (Fig. 28), but if not found it will indicate that the name was either incorrectly spelt, the plant has not been entered into the file, or the plant is hardy.

The "TENDER" species data-file contains approximately 1000 plants all of which are generally considered to be potentially tender in England and Wales. The file is not definitive, and you may enter more names, whenever you wish.

If you are uncertain of the correct spelling of a plant, or just wish to find out which plants are in the data-files, you can ask the program to carry out a search. To perform a search you should type the / character instead of entering a plant name as described above (Fig. 27). You will then be prompted to enter as much of the name as possible, starting with the first letter of the generic name. The program will first search the TENDER species data-file and list all the plants starting with your entry (Fig. 29). Once the plants have been displayed you may select one of them, or force the program to continue the search. If all the file has been checked and no plant has been selected you will be informed that your plant is not in the file.

After selecting a TENDER species the program will display its predicted hardiness rating, and then continue by searching the INTOLERANCE data-file for your selected plant (see 10.16 below). If it is not in the file you will be allowed to either return to the Main Selection Boxes, or carry out a search of the INTOLERANCE file for another plant.

Fig. 29 Carrying out a data-file search.



All plant entries have been HASHED into the data-files, which means that they can usually be retrieved instantly from disc. However, because hashing stores entries in a seemingly random fashion, and the searches are sequential, the plants will not be displayed in alphabetical order.

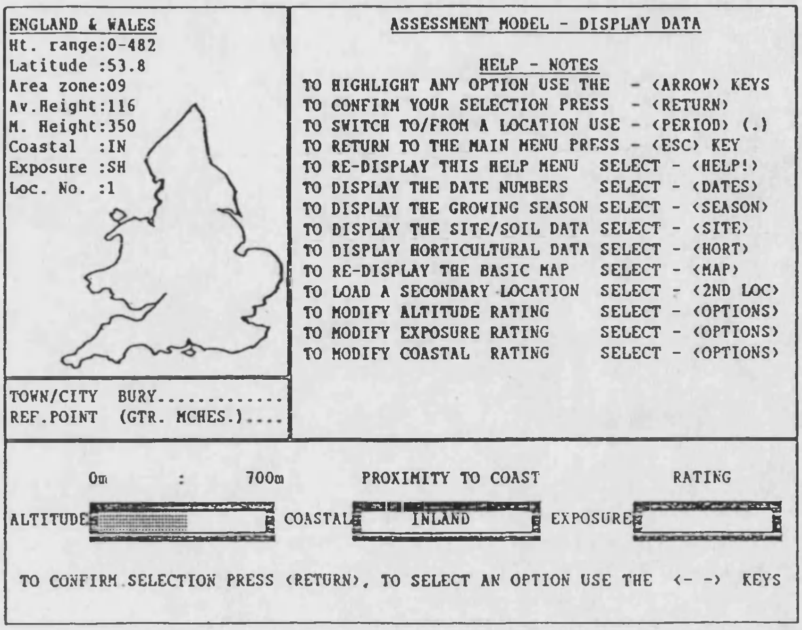
10.16 Plant intolerances.

The majority of plants will establish and subsequently grow in a wide variety of locations and soil types, with problems only arising when certain extreme conditions exist. The assessment program includes a data-file containing all the plants listed in the Joint Council of Landscape Industries plant list. Each taxon in the file has been given an 8 character code; each character relating to one of the following plant intolerance ratings :

1.	Soil texture	: High clay content soils. High sand content soils.
2.	Soil depth	: Shallow soils.
3.	Soil moisture	: Dry soil conditions. Wet soil conditions.
4.	Soil pH	: High pH - alkaline Low pH - acidic soils.
5.	Maritime conditions	: Coastal proximity.
6.	Site exposure	: General site exposure.
7.	Late spring frosts	: Possible damage from late spring frosts.
8.	Seasonal waterlogging	: Seasonally water-logged soils.

After checking the potential hardiness, the program will automatically search through the "INTOLERANCE" data-file in an attempt to load the information about the selected plant. If the file does not contain the entry you will be informed and allowed to select another species. If the entry is found the program will load the relevant information and check to see if any of the intolerance features are inherent to the site. If any are found the program will list them in the main data area (Fig. 30).

Fig. 19. Modifying altitude data.



The program will allow you to set up the climatic and site related criteria and then assess the site suitability for as many plants as you wish. Alternatively, you can enter one species name and then modify the climatic and site criteria to highlight a range of conditions.

When you type in the name of a plant the program remembers it until you enter a new one. This means that you can modify the climatic and site criteria as many times as you wish, but only have to type in the plant name once. On subsequent visits to the "HORT" option, instead of re-typing the name, simply press <RETURN> once and the name will be re-displayed.

10.16.1 Example of displaying plant intolerances.

Re-load the assessment program from the main menu and enter the town name of BURY. Without making any modifications go straight to the "HORT" option and enter the plant name BERBERIS DARWINII. The program will inform you that the plant is not in the tender data-file, which infers that it is hardy in that location. When you press <RETURN> you will be informed that no plant intolerance problems exist. Next, go to the "SITE" option, load information from disc, then ignore the option to view the screens of Notes and Recommendations and return to the Selection Box Menu. Select "HORT" once more and this time the program will display the intolerances as seen in figure 30, i.e. it will see that the site is liable to seasonal waterlogging and that **Berberis darwinii** is intolerant of this condition.

11.0 Data Input.

The second option of the Main Program Menu (Fig. 2) allows you to enter the Data Input program - the initial screen, which is another "MENU", consists of 11 alternatives (Fig. 31).

During data input the various function keys will be outlined in the PROMPT area. You must remember, that individual keys will only become available as and when necessary.

Fig. 31 Data input - selection menu.

```
DATA INPUT - SELECTION  MENU

DATA INPUT SELECTION OPTIONS
----------------------------

 1.  RETURN TO MAIN MENU.
 2.  ENTER NEW CLIMATIC/SITE DATA.
 3.  ENTER NEW SOIL RELATED DATA.
 4.  ENTER NEW TENDER SPECIES.
 5.  ENTER INTOLERANCE DATA.
 6.  MODIFY CLIMATIC/SITE DATA.
 7.  MODIFY SOIL RELATED DATA.
 8.  MODIFY TENDER SPECIES.
 9.  MODIFY INTOLERANCE DATA.
10.  PRODUCE A BLANK DATA-FILE.
11.  PRODUCE HARD COPY.

TYPE THE NUMBER OF THE OPTION, THEN PRESS <RETURN> *
```

You are recommended to make BACK-UP copies of all your data-files before making any modifications to the data. When you have made some copies put the originals away in a safe place and never use them unless your other copies are corrupted. In this way you will always have the basic files to work from.

You can modify any of the data in the data-files; all you need do is to select the correct option from the selection menu and load in the relevant data. It is important to note, however, that you only modify the data in the computer's Random Access Memory (RAM). The information on disc is unaltered until you tell the program to STORE the modifications. So, if you start making some changes and get muddled, or simply decide not to continue with the session you can cancel the modifications and leave everything on disc unchanged.

11.1 Return to main menu.

The first option in the Data Input Menu, i.e. "Return To Main Menu", is the method which allows you to link between data input, the assessment program and returning to the disc operating system (DOS). When you select this choice all disc files are closed and the computer re-loads and runs the Main Menu program.

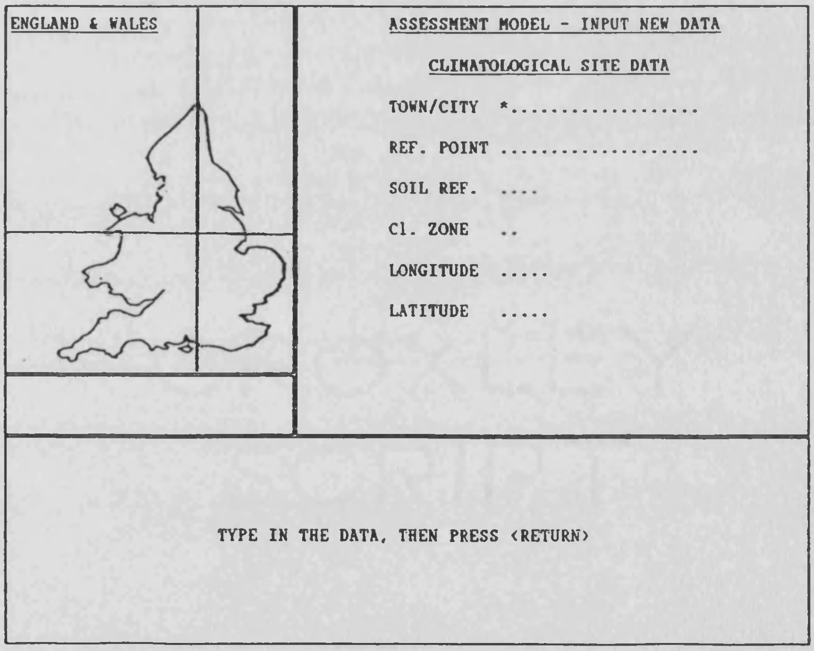
11.2 Entering new climatic data.

You select this option whenever you need to enter a new location for use in the assessment program. The screen (Fig. 32) will display a map of England and Wales in exactly the same position as in the assessment program. The only differences being that 2 lines will be visible crossing through the middle of the map, and the "Notes" headings will be missing.

To the right of the map a number of headings relating to the climate and soil reference type will be printed, these are :

1. Town/city.
2. Reference point.
3. Soil reference number.
4. Climatic zone.
5. Longitude.
6. Latitude.

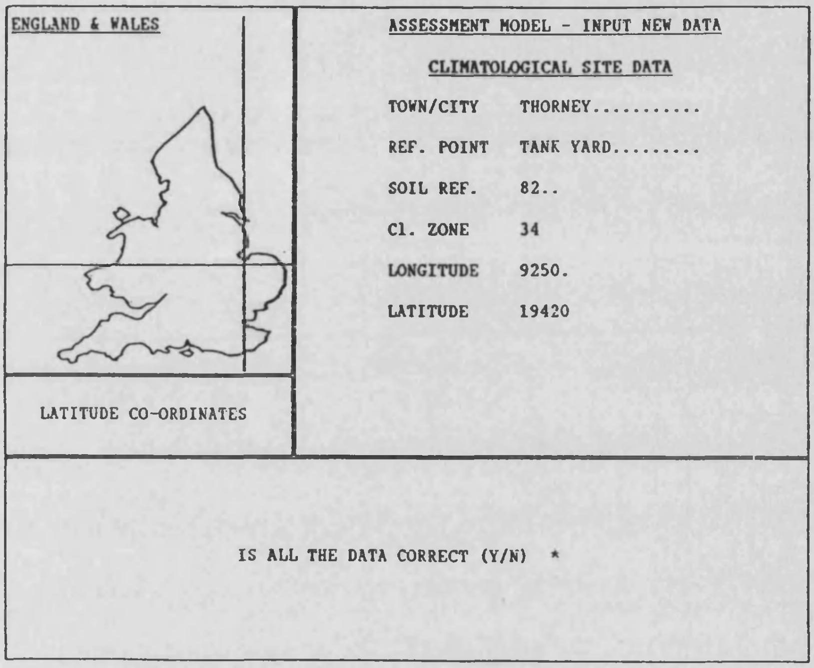
Fig. 32. ENTERING NEW CLIMATIC/SITE DATA - BASIC SCREEN.



Immediately to the right of each heading you will see a row of periods (full stops). The periods indicate the maximum number of characters you may enter. Each row of periods constitute an INPUT FIELD, and all 6 of the input fields make up a RECORD.

Start your entry by typing the name of the town or city which you wish to refer to (Fig. 33). The name you type will be the one used later to call the location in the assessment program - so remember its spelling!

Fig. 33. ENTERING NEW CLIMATIC/SITE DATA.



You can delete characters during input by using the "DELETE CHARACTER" key, remember, that's the one directly above <RETURN>, and you can cancel all input by pressing <ESC>. After checking that the spelling of the location is correct confirm your entry by pressing <RETURN>. The STAR cursor will then jump down to the Reference Point input field and wait for your next entry.

The Reference point allows you to store some special information relating to the location. It may be where the site is within the town, or simply a message to remind you about a feature of the site. Enter the information in exactly the same way as you entered the town name.

Data entry into the Soil reference point is slightly complex. This is a number used to inform the assessment program which soil type is present on the site. To obtain the correct reference number you must first find the relevant "MAP SYMBOL" on the Soil Survey of England and Wales 1:250,000 soil maps, and then use the reference point table in appendix E. If you do not have a copy of the Soil Survey maps it may be possible to identify a common soil type by referencing a number of other pre-programmed sites close to your new proposed entry.

England and Wales have been divided into 70 climatic zones (Appendix A), each of which has a discernible climate. The entry of the correct climatic zone is critical. If you enter an incorrect one the assessment program will display totally false information. To find the correct zone use the climatic zone maps (Appendix A, Figs. 2-12). Locate the position of your site on the relevant map and note the number of the zone in which it is found.

If you find that your site is on the boundary of two zones it may be worthwhile to enter one of the zone numbers and then check a number of climatic parameters in the assessment program, e.g. annual rainfall and air temperatures. If these do not tally with your site use the alternative zone number. Mean annual rainfall and air temperature figures, used for these comparisons, can be obtained from the Meteorological Office, or from the HMSO publication entitled "The Agricultural Climate Of England and Wales".

After entering the Climatic Zone the program will allow you to locate the position of your site on the display map. To do this you use the ARROW keys to move the 2 crossing lines displayed on the map. The first line to move will be the vertical one indicating the "Longitude co-ordinate" of your site. As you move the line across the screen the number in the longitude input field will change. The number is a "screen display co-ordinate", not the actual longitude of the site.

Having positioned the vertical line over where your site is located press <RETURN>. Then using the ARROW keys once more, begin to move the horizontal line, that is the "latitude co-ordinate". Where the 2 lines cross will be the location of your site, i.e. the location of where the black and yellow rectangles will be printed in the assessment program. If you find you need to make an adjustment of the longitude co-ordinate whilst moving the latitude line, simply press <ESC>, make the necessary adjustment using the ARROW keys and press <RETURN>.

When all the data has been entered the program will ask if all the entries are correct. If not, you will be allowed to modify them. If they are correct you will be allowed to store the whole record onto disc and then use the site within the assessment program.

11.3 Entering new soil related data.

The Soil survey of England and Wales publishes a series of 1:250,000 scale maps describing the various soil associations found in England and Wales. The maps describe a total of 297 associations, and in the "Legend" supplied with the maps there is a brief description of each one. The format of the descriptions in the assessment program (Fig. 34) follows that of the Legend, although because of memory restrictions, some of the basic classification details have been omitted.

The data-files contain information relating to all 297 soil associations, which means that additional soil information is unnecessary. However, the program is designed to allow the addition/modification of all data, and for completeness new soil entries have been catered for.

Fig. 34 Entering new Soil Survey of England & Wales data.

```
                    ASSESSMENT MODEL - DISPLAY SOIL DATA

                      SOIL SURVEY OF ENGLAND & WALES
FILE NO. : *..
MAP/SUBGROUP                  : ......
SOIL ASSOCIATION              : .............................
SOIL MAP SYMBOL               : .......................................
SOIL MAP SYMBOL NUMBER        : ....

ANC. SUBGROUPS & SERIES(1)    : .............................
ANC. SUBGROUPS & SERIES(2)    : .............................
ANC. SUBGROUPS & SERIES(3)    : .............................
ANC. SUBGROUPS & SERIES(4)    : .............................

GEOLOGY(1)                    : .............................
GEOLOGY(2)                    : .............................
GEOLOGY(3)                    : .............................
GEOLOGY(4)                    : .............................

SOIL/SITE CHARACTERISTICS(1)  : ..............................................
SOIL/SITE CHARACTERISTICS(2)  : ..............................................
SOIL/SITE CHARACTERISTICS(3)  : ..............................................
SOIL/SITE CHARACTERISTICS(4)  : ..............................................
SOIL/SITE CHARACTERISTICS(5)  : ..............................................
SOIL/SITE CHARACTERISTICS(6)  : ..............................................

CROPPING AND LAND USE(1)      : .......................................
CROPPING AND LAND USE(2)      : .......................................
CROPPING AND LAND USE(3)      : .......................................
CROPPING AND LAND USE(4)      : .......................................

AREA (Sq. Kilometres)         : ...........

                    TYPE IN THE DATA, THEN PRESS <RETURN>
```

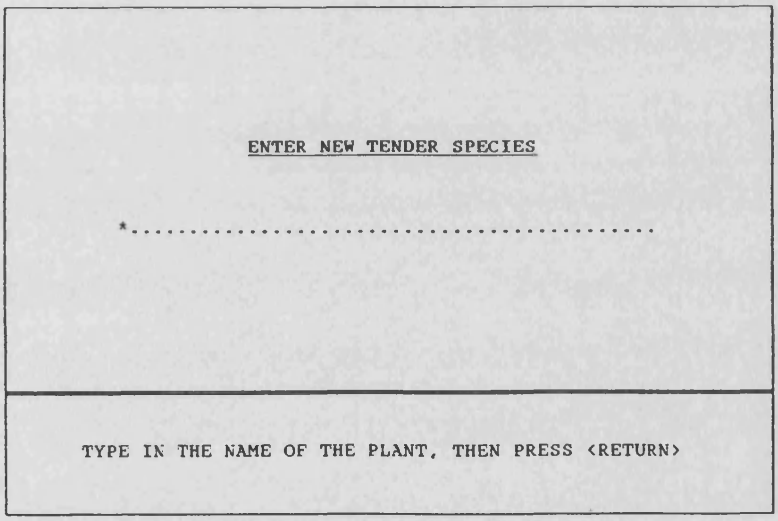
11.4 Entering additional tender species.

The assessment program contains a data-file of plants which are generally accepted as being potentially frost-tender in the majority of locations in England and Wales. Approximately 1,000 plants have been pre-coded (Appendix C), although you can add more if you wish.

When checking if a plant is potentially frost tender all that the assessment program does is to look for a specified entry in the file. If it is found you are informed that the plant is potentially tender, otherwise you are told that the entry is not in the file. You must realise that only a direct check is made, and that no information, other than the plant name, is stored in the file.

To enter new tender species into the file select item number 4 of the Data Input menu. A new screen display (Fig. 35) will be printed and you will be prompted to enter the plant name. Having typed the name confirm that it is correct by pressing <RETURN>. The program will then ask if you wish to save it to disk. Once it is saved you will have the option of entering another plant, or returning to the main menu.

Fig. 35 DATA INPUT - ENTER NEW TENDER SPECIES.



11.5 Entering intolerance data.

The majority of plants will grow in a wide range of climatic and site conditions, with problems only arising when extremes are experienced. The assessment program allows you to enter plant names and codes, into a data-file, which indicate the possibility of potential intolerance to adverse growing conditions. The data-file (Appendix D) is pre-recorded with all the plants listed in the Joint Council of Landscape Industries plant list, although you can include new entries as and when you wish. The following eight intolerance categories with their various selection options are available :

1.	Soil texture	: Undemanding. No data available. High clay content soils. High sand content soils.
2.	Soil depth	: Undemanding. No data available. Shallow soils.
3.	Soil moisture	: Undemanding. No data available. Dry soil conditions. Wet soil conditions.
4.	Soil pH	: Undemanding. No data available. High pH - alkaline soil. Low pH - acidic soil.
5.	Maritime conditions	: No data available. Tolerant of coastal proximity.

Intolerant of coastal proximity.

6. Site exposure : No data available.
All but very sheltered sites.
All but sheltered sites.
Exposed sites.
Extreme exposure.

7. Late spring frosts : No data available.
Tolerant of late spring frosts.
Intolerant of late spring frosts.

8. Seasonal waterlogging : No data available.
Tolerant of seasonal waterlogging.
Intolerant of seasonal waterlogging.

When you initially select option number 5 of the data input main menu the program will display a new screen (Fig. 36) which indicates the various intolerance options.

To begin input you must first enter the plant name and confirm that it is correct by pressing <RETURN>. The program will then list the available intolerance options relating to each heading in turn. To scroll through the options use the ARROW keys and when the individual option you require is displayed on the screen you can confirm your choice by pressing <RETURN>.

Fig. 36 DATA INPUT - ENTERING INTOLERANCE DATA.

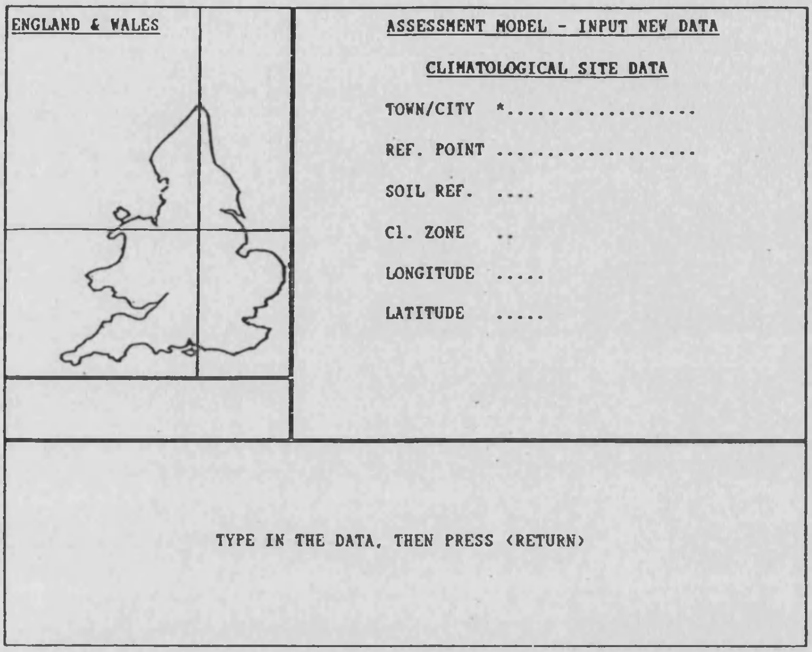
```
SPECIFIC SITE RELATED PLANT INTOLERANCES

TAXON NAME : ..........................................

SOIL TEXTURE           : UNDEMANDING
SOIL DEPTH             : UNDEMANDING
SOIL MOISTURE          : UNDEMANDING
SOIL pH                : UNDEMANDING
MARITIME CONDITIONS    : NO DATA AVAILABLE
SITE EXPOSURE          : NO DATA AVAILABLE
LATE SPRING FROSTS     : NO DATA AVAILABLE
SEASONAL WATERLOGGING  : NO DATA AVAILABLE

TO CONFIRM SELECTION PRESS <RETURN>, TO SELECT AN OPTION USE <- -> KEYS
```

After completing all your selections the program will ask if everything is correct. If not, you will be given the opportunity to correct your entries. If everything is ok then you can save the whole record to disc.

11.6 Modifying climatic/site data.

Option 6 of the data input menu allows you to modify the climatic/site data. The basic display screen will be exactly the same as for entering new data (Fig. 33 & 37), the only difference being that you first specify the location name and the program loads the pre-programmed data from disc. If the entry is not found you will be informed and allowed to have another try.

Fig. 37. MODIFYING CLIMATIC/SITE DATA - BASIC SCREEN.



All the data is stored on disc using a special "HASHING" routine which allows extremely rapid disc accesses. In most cases your entry will be retrieved within a second or two.

Having found the entry the program will display the data on the screen and you will be allowed to modify everything except the location name. If you wish to leave any of the information unchanged simply press <RETURN> whilst the STAR cursor is at the left most position of the INPUT FIELD. When complete, the program will enquire if the entry is correct. If it is you can store the information to disc, if incorrect you will be allowed to re-modify it.

You should note that you only change the data on disc when you actually make a store command. You can make as many changes to the displayed data as you wish, but until you tell the computer to save it the data will only be modified in the computer's RAM memory. This is important, because if you make some changes to the displayed data, and then wish to discard them you only need to cancel the entry and the changes will not affect your disc data-file.

11.7 Modifying the Soil related data.

All the data supplied by the Soil Survey of England and Wales is pre-recorded and should not require any modifications. You may change the entries if you wish, but it is not recommended.

Modifying the "Tender" plant data file.

The tender species data-file consists of a list of plants which are generally recognised to be frost tender in England and Wales. No other information is stored in the file. The only reason why you should wish to modify this data is if you find that a name is spelt incorrectly, or if a plant has had its name changed and you wish to remain up to date.

To modify an entry all you need do is type in the plant name. The program will locate it from disc and display it on the screen. You may then enter the modified name and confirm that it is correct by pressing <RETURN>.

Once you store it on disc the old name will be deleted and the new one stored in its place. As the names are stored using a "HASH" code do not expect to find the modified entry in exactly the same place in the data-file as the old name.

11.9 Modifying intolerance data.

All of the plant names in the data-file have been based on the Joint Council for Landscape Industries plant list, although the data relating to the specific intolerances have been compiled from a wide range of horticultural literature. Approximately 1500 taxa have been included in the data-file and each has an eight digit code relating to the intolerances listed in 11.5 above. When you select to modify this information the program will display the same basic screen as when entering new plants (Fig. 37) and you follow the same overall procedure.

You begin modification by typing in the plant name. The program will search the data-files for the entry, and if located, the current setting for each of the parameters will be printed on the screen. You may then scroll through the various options and re-select them. If you wish to retain a setting, just press <RETURN> whilst the STAR cursor is in the left-most input field setting. On completion you will be given the option to save the new information and the opportunity to modify more entries if required.

Fig. 38 DATA INPUT - MODIFYING INTOLERANCE DATA.

```
              SPECIFIC SITE RELATED PLANT INTOLERANCES

      TAXON NAME : ..........................................

              SOIL TEXTURE           : UNDEMANDING
              SOIL DEPTH             : UNDEMANDING
              SOIL MOISTURE          : UNDEMANDING
              SOIL pH                : UNDEMANDING
              MARITIME CONDITIONS    : NO DATA AVAILABLE
              SITE EXPOSURE          : NO DATA AVAILABLE
              LATE SPRING FROSTS     : NO DATA AVAILABLE
              SEASONAL WATERLOGGING  : NO DATA AVAILABLE

  TO CONFIRM SELECTION PRESS <RETURN>, TO SELECT AN OPTION USE <- -> KEYS
```

11.10 Producing blank data-files.

The data input program will allow you to clear all of the information from the various data-files, thus producing a completely blank data bank. You can specify which individual files to clear, but you should remember that once you select the option all of the selected data will be lost forever.

Using this option allows you to create personalised data-files which may be suited for specific locations or individual design specifications /

applications. It is recommended that you only clear "copies" of the original data-files, never the originals. In this way you will always be able to return to a known set of parameters.

11.11 Producing hard copy.

If you have a suitable printer connected to your computer the program will allow the production of lists of data relating to the various data-files. The data in the files is not stored in alphabetical order; it is stored using a "HASH" code. Hashing is a method used to store information, in a seemingly random fashion, but in such a way that its retrieval from disc can be extremely fast. The information will be printed as it is found on disc, i.e. not in alphabetical order.

If for any reason your printer is not ready, or there is no paper loaded the program will "HANG UP" and wait for the error to be corrected.

INDEX

ABSOLUTE MEMORY ADDRESS : A number (address) relating to a specific portion of code. In BASIC, programs are stored as a list of lines. Each line is not available as an absolute memory address which means that during execution of statements, such as, GOTO's, the BASIC interpreter must examine each line number of the program, starting with line one, until the specific referenced line number is found. In compiled programs, e.g., "C" a new program called an "Object Module" is produced which contains a machine code form of the program. During compilation the program is changed into relocatable machine code, i.e. the actual language of the computer. In doing so, the compiler allocates memory addresses to each specific program statement. In this way all translations are made before the program is run and the computer can then utilise the memory addresses instead of checking the whole program line by line.

ADDRESS : A number used to identify a specific location in a computer's memory.

ADDRESSABLE MEMORY : Computer memory is a collection of sequential locations; each location having a unique address. The amount of memory which can be used (addressed) by a computer is controlled by individual micro-processors. For example, the 8080 can address approximately 65,000 locations, whereas the 8086 can address over one million. Other more modern processors can address in excess of one billion memory locations.

ADJUSTMENT FACTOR : Adjustment factors allow users of the assessment program to modify the climate and site related parameters.

ALPHANUMERIC DATA : Data containing both letters and numbers, or any other symbol that belongs to a character set.

ALGOL : A programming language. short for Algorithmic language. first appeared in 1958 and was originally called Algol 58.

ARROW KEYS : The four keys, found at the base of the word-processor keys and between the calculator pad and the main keyboard. Their function is to allow the SCROLLING of options.

ASCI : An acronym for the American Standard Code for Information, which is a widely accepted set of characters using the numbers 1 to 127 to represent alphanumeric information.

ATTRIBUTE : A solitary characteristic. Each attribute is stored in an input field, and a collection of attributes make up a record.

AUTO EXECUTE BATCH FILE : A file stored on disc which controls a series of computer functions. An automatic execute batch file is used by many micro-computers to allow a number of pre-determined operations to be carried out immediately after the computer has been switched on.

AVAILABLE MEMORY : The computer memory which is available to the user, i.e. the memory which holds programs and data.

BACK-OUT : Return to a previous section of the program. In the case of the assessment program this is performed by using the ESCape key.

BACK-SLASH : A keyboard key (/) positioned at the bottom right hand corner of the main keyboard and housed on the same key as the question mark. In the assessment program its function is to allow the user to view selected and selectable attributes.

BACKSPACE : Refers to the BACKSPACE key which is positioned directly beneath FUNCTION keys 11 and 12, and immediately above the RETURN key. It is used to delete characters and correct errors during data input.

BASIC : A high level scientific programming language. It was introduced in 1965 and the word BASIC is an acronym for Beginner's All Purpose Symbolic Instruction Code. Many versions exist the industry standards being Microsoft and G.W. BASIC.

BENCHMARK : A series of routines to test the speed of operation of a micro-computer.

BATCH FILE : A file which performs a series of pre-determined operations (see Auto execute batch file).

BINARY : Data that is encoded using only the symbols 0 and 1.

BIOS : The computer's Input/Output system. the driver programs in the BIOS define the correspondence of physical device to actual device.

BIT : A binary digit.

BOOT : Restart the computer. A function which clears the computer and loads a program into main storage.

BUG : A programming error.

BYTE : Eight binary digits and the basic unit of data. The term most frequently used to describe the available memory in a computer.

C : A low level programming language. Many versions exist, but the standard is defined by B.W Kernighan and D.M Ritchie, although the new proposed ANSI standard should become available shortly.

CAPS-LOCK key : Abbreviation for capital lock. The key used for changing from lower to upper case and back. The operation is carried out by depressing the key immediately to the left of the letter -A- key on the main IBM keyboard. The assessment program carries out automatic Upper Case conversion during much of the data input phase.

CHARACTER STRING : A series of alphabetic characters, e.g. the name of a plant.

CHARACTER DATA : Information (data) consisting of alphabetic characters.

COBOL : A low level computer programming language. The word COBOL is an acronym for Common Business-Orientated Language.

COMPILER : A program which translates programming languages. Th compiler use in the University of Bath micro-computer based site assessment programs was the Zortech "C" compiler.

CONTINUOUS PAPER : A type of paper (usually perforated and folded) which is used for computer print-out.

COPY ROUTINE : A routine which enables direct copies of other programs to be transferred onto new media, e.g. newly formatted discettes.

CORRECTION FACTOR : A mathematical computational figure which enables the modification of calculations.

CPU : Abbreviation for Central Processing Unit.

CURSOR : The highlighted block, or STAR which indicates where information will be selected, or entered on the display screen.

DATA : Plural for the word datum. Representation in a precise, formalised language of facts or concepts. The data are often either numeric or alphabetic and in a form suitable for manipulation by computational means.

DATABASE : A program which handles the storage, allocation, retrieval and updating of records and can present multiple views of data.

DATABASE GENERATOR : A program which generates database systems. Database generators handle the formatting and structuring of database programs, e.g. Clipper, is a generator which is used to set up database systems using DBASE IV.

DATA-DISCETTE : A discette used for storing information. Computer software packages are usually designed so that the program discette is held in drive -A- and the data-discette is in drive -B-.

DATA-FILE : A computerised file which holds data.

DATA INPUT : The entering of information into the computer. in most database programs data input is rigidly controlled via the main domain statement.

DATA RETRIEVAL : The name given to the process of extracting information from a data-file.

DATA STRING : A collection of numbers, letters, or words which may be stored in a data-file.

DEDICATED SYSTEM : A piece of equipment or software designed to carry out a specific set of operations.

DEFAULT DRIVE : The drive, usually -A- which is logged onto when a program is run, or the drive which the computer program searches through when no drive is pre-specified.

DELETE KEY : The keyboard key which deletes characters from the display screen of the computer.

DISC : Short for discette. the flexible storage medium that stores data and which is placed in the DISC-DRIVE prior to use.

DISCETTE : As DISC above.

DOMAIN STATEMENT : A set of computer commands which control the storage and retrieval of data, and the memory allocation/search options in a database system.

DOUBLE PRECISION : Numbers usually stored as either 16 or 32 digits of precision, and printed with up to 16 or 32 digits.

DRIVE : A mechanical device for reading and writing information stored on magnetic discettes. There are commonly two disc drives fitted to a computer system. Drive -A- is where programs are loaded from disc, and drive -B- where data is usually stored. Winchester disc drives when fitted are usually called drive -C-.

ESCAPE SEQUENCE : A series of events which enable the program user to cancel operations and return to a previously pre-defined condition.

ENTER KEY : Refers to the ENTER key which is usually found at the bottom right hand corner of the numeric keypad. Its function is the same as the RETURN key.

ERROR TRAPPING : A pre-defined system designéd to detect operator and program errors.

ESC : Short for ESCAPE.

ESCAPE KEY : Refers to the ESC labelled key at the top left hand corner of the keyboard.

FIELD : A designated portion of a set of data which can consist of a group of characters or digits, such as a plant name or numeric code. Field types can be decimal number, integer, date, unit of currency, characters, alphanumeric, several bytes worth of free text etc.

FILE : A term usually referring to a complete set of data-file records.

FILE EXTENSION : A three character code appended to the end of a file name. For example, "TENDER.DATA". The file mane is followed by a period and then an extension to signify the type of file, e.g. "DAT" would usually indicate a data file.

FILE NAME : The name which identifies a specific set of data. It can usually consist of up to eight alphanumeric characters, although certain character combinations are not allowed. The identifying name may be followed by a period and a three letter file extension (see FILE EXTENSION above).

<ins>FLOPPY DISC</ins> : See DISC.

<ins>FORMAT</ins> : The way something is set out or designed, e.g. the format utility of MS-DOS organises discettes for system use and, optionally, creates new system discettes.

<ins>FORTRAN</ins> : The oldest high-level programming language for problems of a scientific nature. The first issued version was by IBM in 1954, however, since that date many other versions have been developed.

<ins>FUNCTION KEYS</ins> : Keyboard keys which have been designated special uses, for example, the 12 keys with numbers preceded by the letter -F- at the top of the keyboard are used by many commercial programs and MS-DOS to carry out a series of commands.

<ins>GOSUB</ins> : A program branching statement which allows a series of computer commands to be performed before returning to the position in the program where the GOSUB was encountered.

<ins>GOTO</ins> : A branching statement which unconditionally forces the computer to jump to a different area of a program.

HARD-COPY : Printing information from the computer onto a piece of paper.

HARD DISC : Commonly known as "Winchester" discs. They are types of mass storage devices.

HARDWARE : Any physical piece of computer equipment, e.g. printer or Winchester disc (programs are commonly known as software).

HIGHLIGHT : A method of making a statement or data more easily visible to the computer user.

INDEX KEY : A field or expression (also known as a key identifier) used to select and sort data records. Sorting a database on a particular key identifier, e.g. a plant name, allows its contents to be viewed in a logical order opposed to the order of data entry.

INDEX FILE : A file which stores information relating to "Index keyed" data. for example, an index file could be created, via an index key, which would store the file positions of all plants intolerant of salt laden winds.

INPUT : Typing information into the computer.

INPUT FIELD : See FIELD.

INTEGER : A whole number with no decimal fraction.

INTEGRATED PACKAGE : A collection of computer programs which can generate/manipulate inter-usable data.

<u>INTERACTIVE INPUT</u> : A method of operation whereby the user can be in constant communication with the computer, usually via a console (VDU).

<u>INTERACTIVE MODEL</u> : A computer program which allows interactive input, i.e. data input and subsequent viewing/manipulation of results.

<u>JUMP</u> : Describes rapid movement through a file or to a new section of a program.

<u>KBYTE</u> : Short for Kilobyte.

<u>KILOBYTE</u> : One thousand and twenty four bytes of memory. Commonly refers to one thousand bytes of memory.

<u>KEYBOARD</u> : A typewriter style set of keys which allow the input of data into the computer. A means of allowing interaction between the user and the program.

<u>KEY IDENTIFIER</u> : See INDEX KEY.

<u>LOAD</u> : Put a program or some data into computer memory.

<u>LOCK-UP</u> : A computer may, under certain circumstances, cease to function until a pre-defined condition exists, e.g. you may have asked it to print something on the printer without switching the printer on. the computer will wait until the printer

is switched on before it continues.

LOG-ON : A pre-defined system used to switch on the computer and allow interactive input, or the viewing of data. It is also used in terms of connecting computers together via telephone cables and modems.

LOGICAL OPERATORS : A series of keys which allow tests to be performed on multiple relations, bit manipulation, or Boolean operations.

LOWER CASE : Small letters (See UPPER CASE).

MACHINE CODE : The program code generated by machine language.

MACHINE LANGUAGE : A language which directly governs a computer's actions, as it is interpreted by a computers circuitry.

MAGNETIC DISC : A medium for storage of computer data (often called "Floppy Discs").

MAGNETIC TAPE : A device for mass storage of data, typically used on mainframe computers.

MASS STORAGE DEVICE : Any device which stores large quantities of data, e.g. Winchester and Floppy discs.

MASTER DISC : The discette containing the master programs.

MAIN MENU : The list of selectable options at the beginning of a program. A "MENU" is simply a list of options.

MASTER PROGRAM DISCETTE : The discette containing a copy of the original master programs. As soon as the master discette is obtained the user should copy it on to a blank discette and then store the original in a safe place.

MBYTE : Short for Megabyte.

MEGABYTE : One million bytes of memory.

MEMORY SEGMENTATION : The division of computer memory into code data, and stack segments.

MENU : A list of various options.

MICROPROCESSOR : A single computer chip - usually consisting of a control unit, an arithmetic and logical unit, registers, flags, and interfaces to both memory and input/output devices.

MONITOR : Commonly used to describe the computer video display unit, i.e. the display screen. It can also be used to describe a computer program which enables the user to perform memory manipulation.

MS-DOS : Microsoft's disc operating system.

NUMERIC DATA : Data consisting of numbers.

OBJECT CODE : A type of intermediate state between Low and High level computer languages. Object code is generated during compilation of programs.

<u>OPERATOR ERRORS</u> : Errors which are made by users of computers and computer programs.

<u>OVERLAY</u> : A memory saving programming technique allowing small portions of code to be added, or merged, into the master programs during execution.

<u>PASCAL</u> : A low level programming language.

<u>PERIOD KEY</u> : A full stop (.).

<u>PERIPHERAL</u> : The general term given to equipment, e.g. printers, which are used on micro-computers.

<u>PRIMARY SEARCH KEY</u> : An item of data, e.g. a plant name, used to extract and manipulate data-file records.

<u>PRINT-OUT</u> : computer generated information printed onto paper.

<u>PROCEDURE</u> : A BASIC programming feature which allows conditional branching and the initialisation of a number of pre-defined operations. On completion the program will return to the statement following the procedural call.

<u>PROCEDURAL LANGUAGE</u> : A programming language which is usually built into a database and which is structured in terms of procedures the system must follow in order to carry out a task.

PROMPT MESSAGE : A sentence or note indicating some form of action, e.g., computer input/output.

QUERY : A specific request for information from a database.

RANDOM ACCESS file : A computer data-file which stores information in a packed binary format. The data can be accessed randomly, i.e. from anywhere on the disc, it is not necessary for all of the information to be read as in sequential files.

RAM : Random access memory. User available memory.

RECORD : A group of logically related data fields, e.g. all information relating to an individual species.

RECORD NUMBER : A number which directly relates to the position of an individual record in a computer data-file.

RELATIONAL DATABASE : A database which can handle multiple files simultaneously and can sort through large volumes of files and display or print their relationships.

RELATIONAL FILE : A file in which records are logically inter-related on the basis of common data.

REM : A shortened form of the word REMARK.

REMARKS : Brief notes encoded into the computer program to increase the readability and ease of understanding of the program.

RESET : Clearing everything from a computer's memory, and starting again. Usually done by pressing the RESET button (see below).

RESET BUTTON : A button or switch which enables the user to clear the computer's memory and start at the stage directly following "Power Up". It is a method used to re-boot the system without first switching the computer off.

RETRIEVAL STATEMENT : The method used to retrieve information from computerised databases. In large systems the complexity of the retrieval statement can be considerable, whereas on micro-computers it is usually relatively straightforward.

RETURN KEY : Indicates the RETURN or ENTER key.

RUN : Make a program start to work.

SCROLL : Move through a list of options.

SEQUENTIAL FILE : A sequential data-file contains information in a series of ASCI characters stored one item after another (sequentially).

SEQUENTIAL SEARCH : A sequential search consists of checking each item of information in a data-file one after the other. To carry out a complete search the first item would be checked followed by the second and so on until the "End of File" marker is encountered.

<u>SET-UP</u> : Prepare for use.

<u>SILICON CHIP</u> : A slither of silicon containing a microprocessor.

<u>SINGLE PRECISION</u> : On 8 bit computers, numbers stored with seven digits of precision and printed with seven digits of precision. On modern micro-computers a single precision number can be much larger than 7 digits.

<u>SOFTWARE</u> : Computer programs.

<u>SOURCE CODE</u> : The original copy of a program in either high or low level language.

<u>SPACE BAR</u> : The long key at the base of the keyboard. It is used to place blank spaces between works.

<u>SPREAD-SHEET</u> : A computer program designed to enable the solving of mathematical problems.

<u>STATE OF THE ART</u> : "Up To Date", or the "most Modern Development". Usually in reference to the micro-computer industry.

<u>STRING</u> : A finite series of zero or more symbols.

<u>TERMINAL</u> : A typewriter style keyboard allowing access to a computer.

<u>TOGGLE</u> : Switch from one point of a program to

another, or switch on/off a special feature, e.g. you may toggle from the first to second location using the period key.

UPDATE : Make a new copy containing new data.

UPPER CASE : Capital letters.

USER FRIENDLY : A computer term meaning "Easy to Use and Understand".

VARIABLE : A quantity in a program which may possess different values as the program proceeds.

VDU : Acronym for Video display Unit, i.e. the television-like screen. It is also often called a monitor.

VIDEO DISPLAY : The image of information printed onto the video display unit.

WINCHESTER : The name given to a mass storage device.

WORD PROCESSOR : A piece of software (program) to enable the writing of documents.

WRITE PROTECT : Prevent information from being accidentally stored or deleted from a discette.

WRITE PROTECT TAB : A small piece of sticky tape, or a removable plastic tab. It prevents information from being stored or deleted from a discette.

PLANTING SITE LOCATION

Method :

1. Locate the planting site position on the relevant 1:50,000 Ordnance Survey Landranger map series. It is possible to use other maps, e.g. Ordnance Survey road atlases, but when these are used calculations of grid references can become more difficult.

2. Check the approximate planting site location on the map of England and Wales (Fig. 1) and using the Landranger map sheet numbers listed below, select the relevant individual reference map (Figs. 2 to 11).

3. Small numerals at the edges of the reference map grids indicate the specific 1:50,000 Ordnance Survey grid co-ordinates.

4. The large numbers printed within the grids are the individual Zone reference numbers. These numbers are used by the program to calculate climate related attributes.

5. Using the Ordnance Survey grid co-ordinates (calculated via the Landranger or similar series) locate the planting site on the individual climate related maps (Fig. 2-11). The area in which the planting site falls is the planting site climatic zone.

APPENDIX A

PLANTING SITE LOCATION MAPS

PLANTING SITE LOCATION

Method :

1. Locate the planting site position on the relevant 1:50,000 Ordnance Survey Landranger map series. It is possible to use other maps, e.g. Ordnance Survey road atlases, but when these are used calculations of grid references can become more difficult.

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5. Using the Ordnance Survey grid co-ordinates (calculated via the Landranger or similar series) locate the planting site on the individual climate related maps (Fig. 2-11). The area in which the planting site falls is the planting site climatic zone.

ORDNANCE SURVEY 1:50,000 MAP SHEET NUMBERS

CLIMATE MAP NUMBER	1:50,000 SHEET NUMBERS IN ORDER ACROSS THE INDIVIDUAL MAP PAGES.
2	74,75.
3	80,81.
4	96,97,98,99.
	102,104,104.
	108,108,110.
	114,115,116,117,118,119.
	123,124,125,126,127,128.
5	99,100,101.
	104,105,106,107.
	110,111,112,113.
	119,120,121,122.
	128,129,130,131,132,133,134.
6	124,125,125.
	135,136,137.
	145,146,147,148,149.
	157,158,159,160,161.
	170,171.
	182.
7	126,127,128,129,131.
	137,138,139,140,141,142,143.
	149,150,151,152,153,154.
	161,162,163,164,165,166,167.
	171,172,173,174,175,176,177.
8	132,133,134.
	143.

	154,155,156.
	167,168,169.
	177,178,179.
9	180,181,182.
	190,191,192.
	200,201,202.
	203,204.
10	172,173,174.
	182,183,184,185,186,187.
	193,194,195,196,197,198.
11	178,179.
	188,189.
	199.

Fig. 1 Reference Areas of Climate

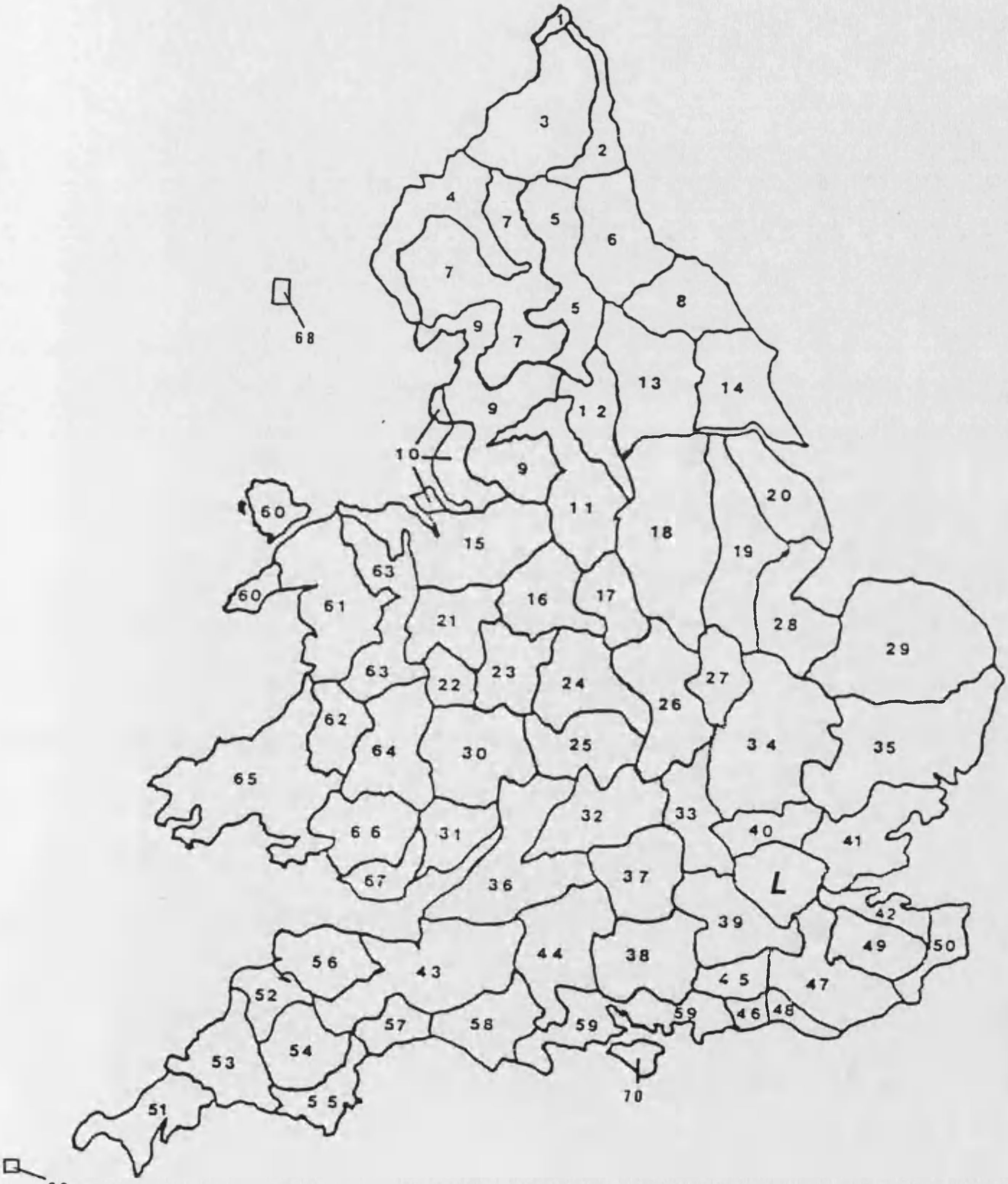


Fig. 2 Northumberland and the Borders

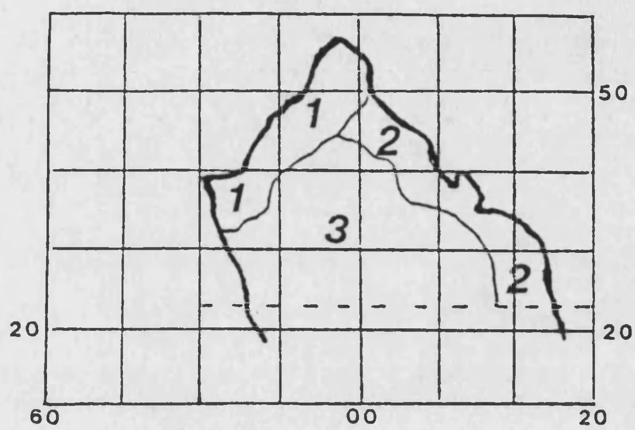


Fig. 3 Northern England

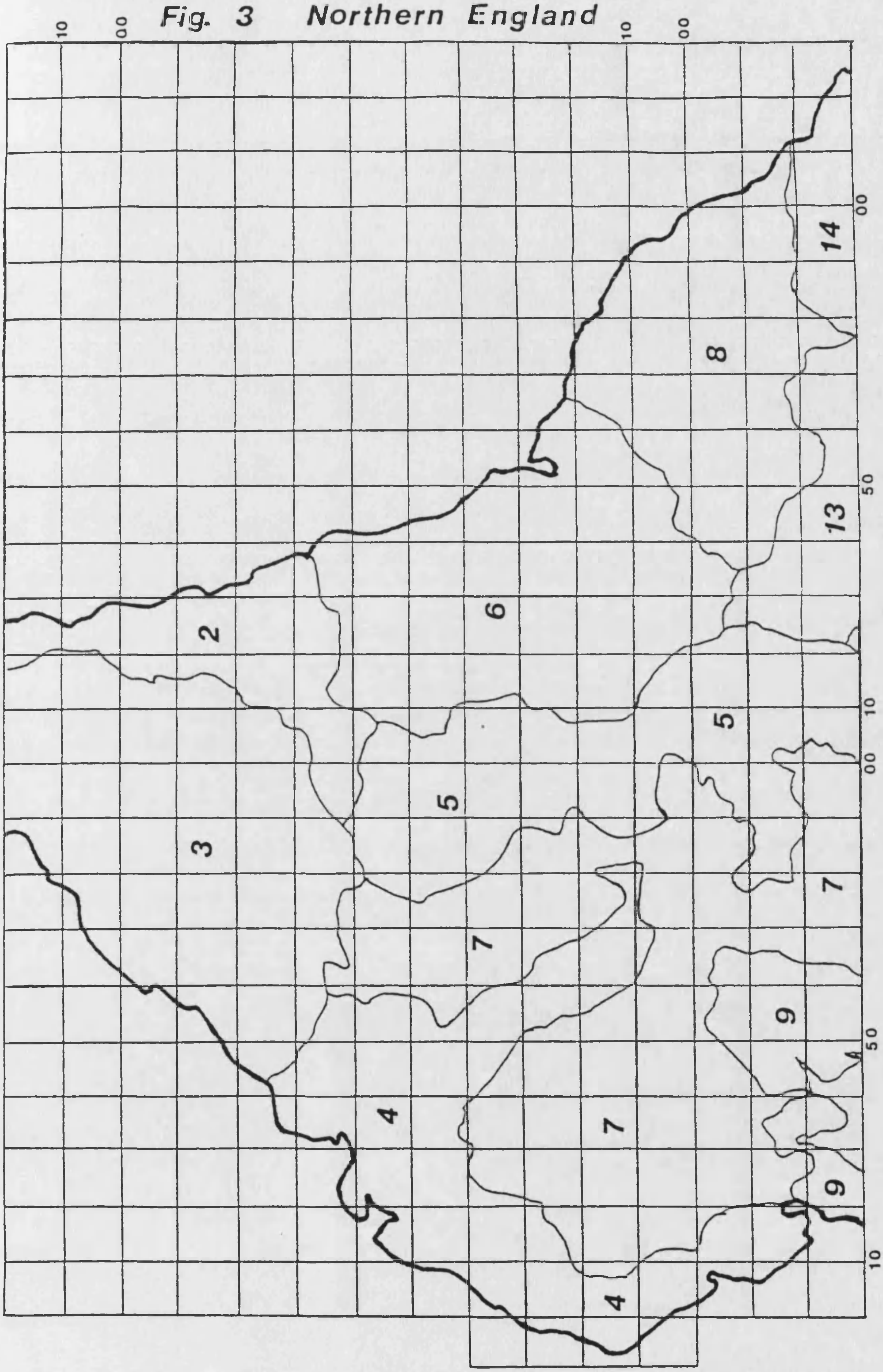
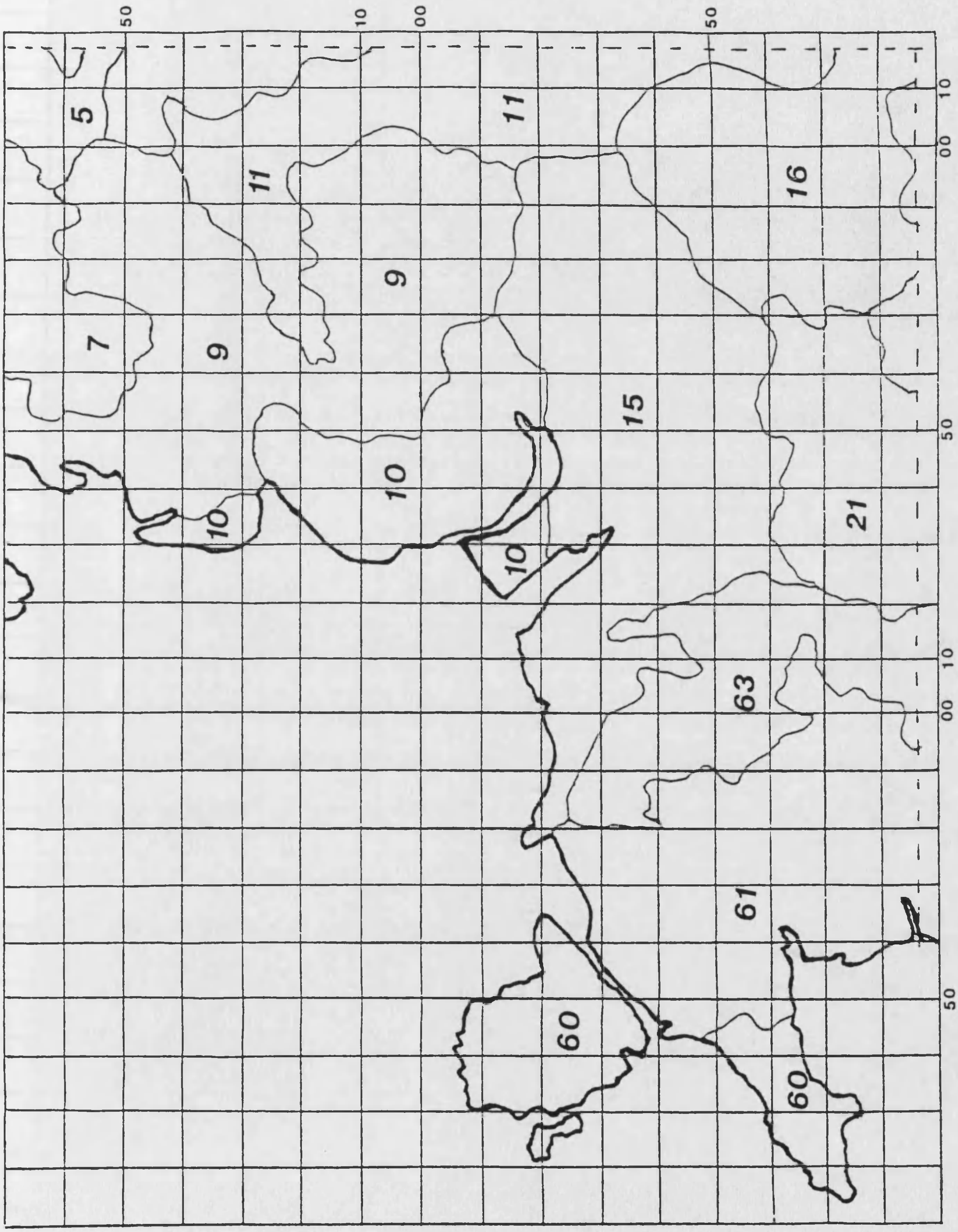


Fig. 4 North Wales



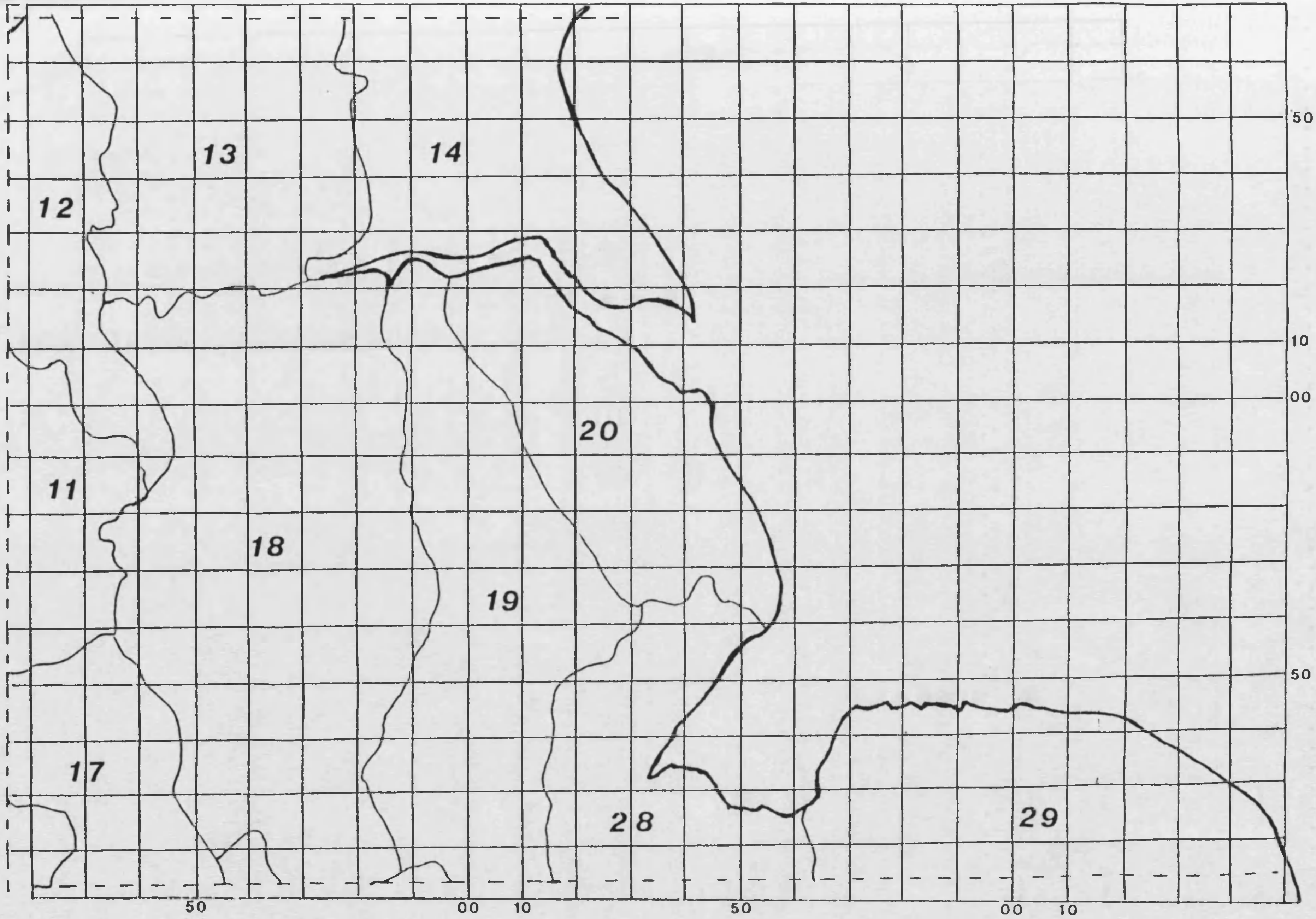


Fig. 5 Eastern England

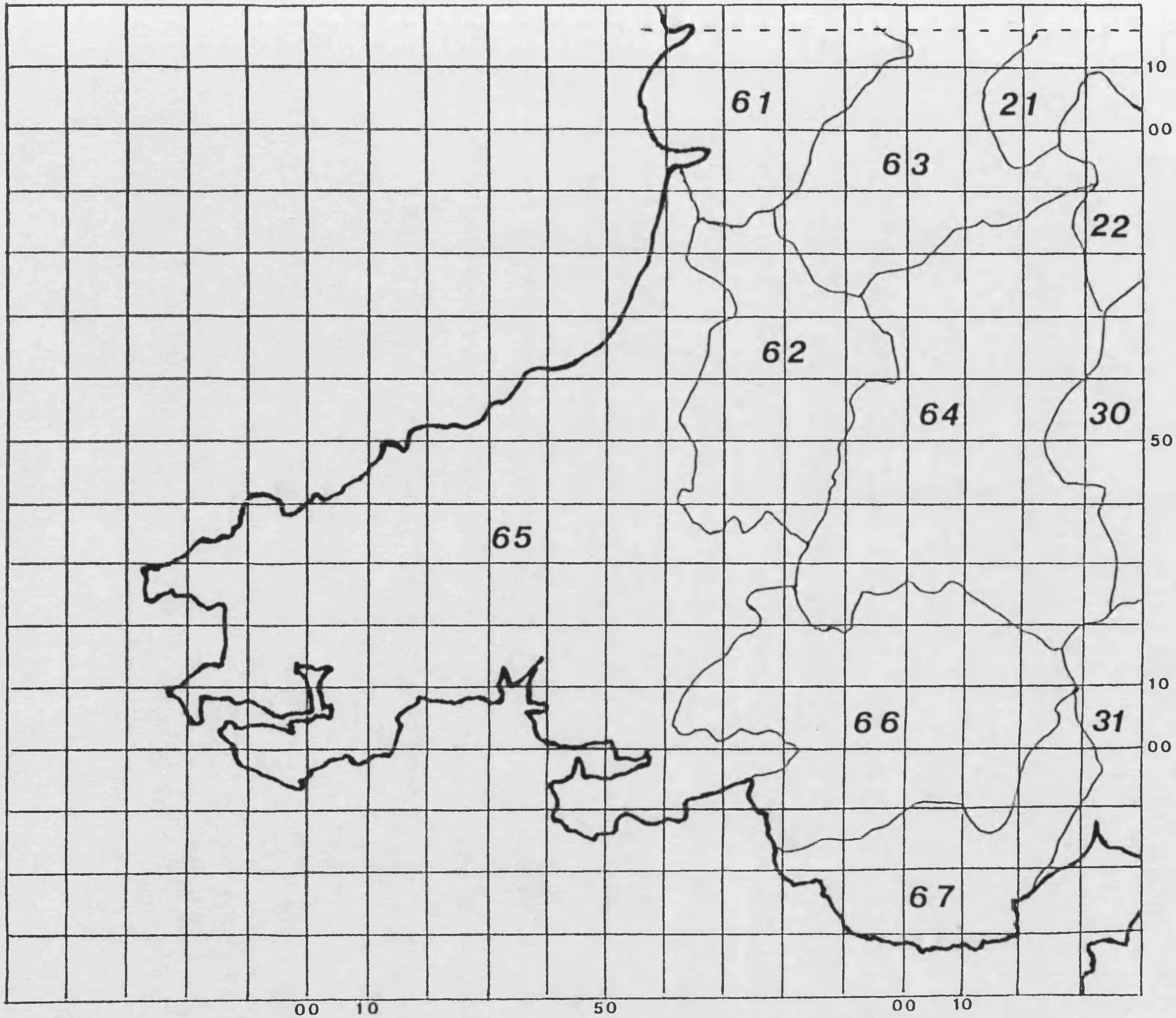


Fig. 6 Wales

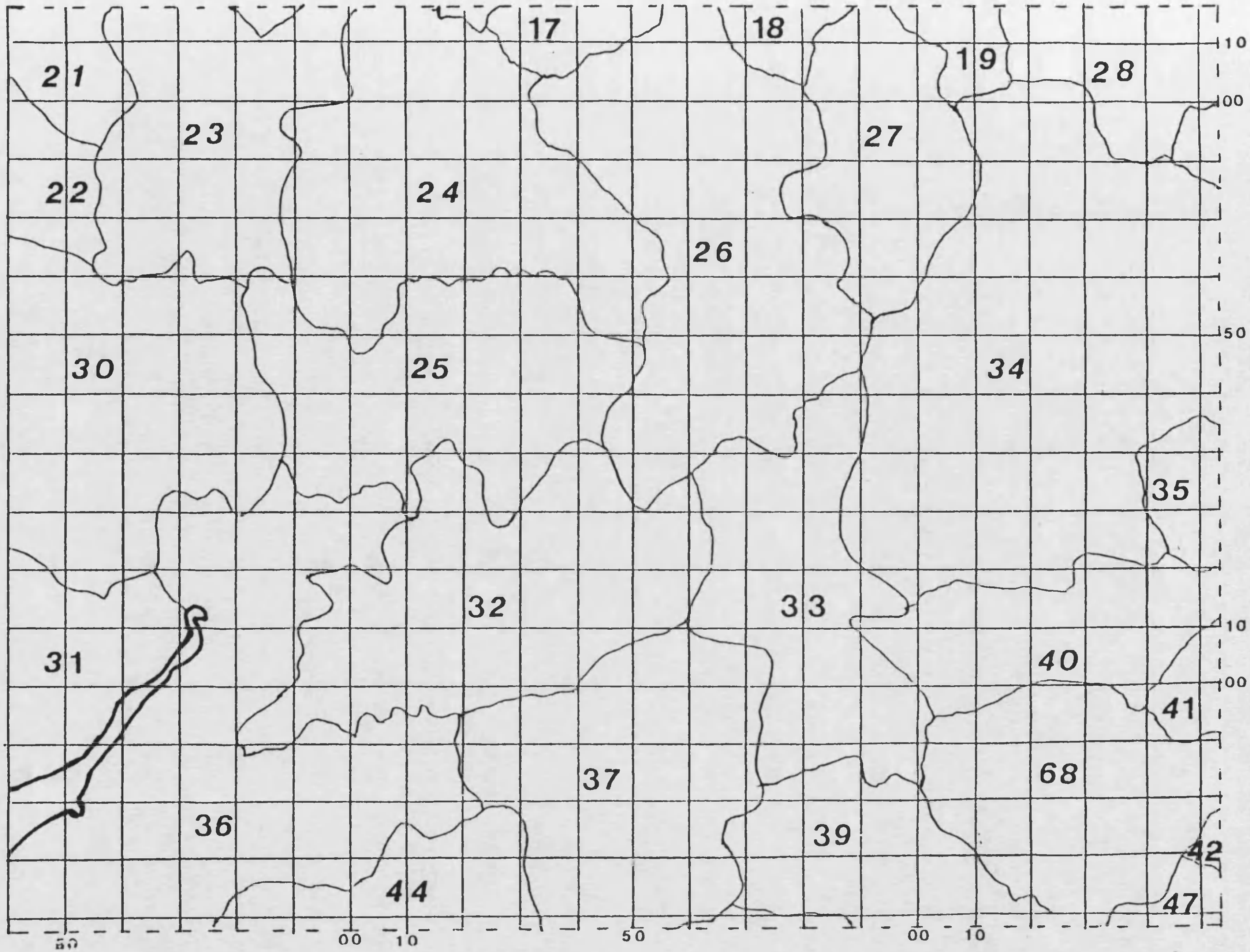


Fig. 7 Midlands

Fig. 8 East Anglia

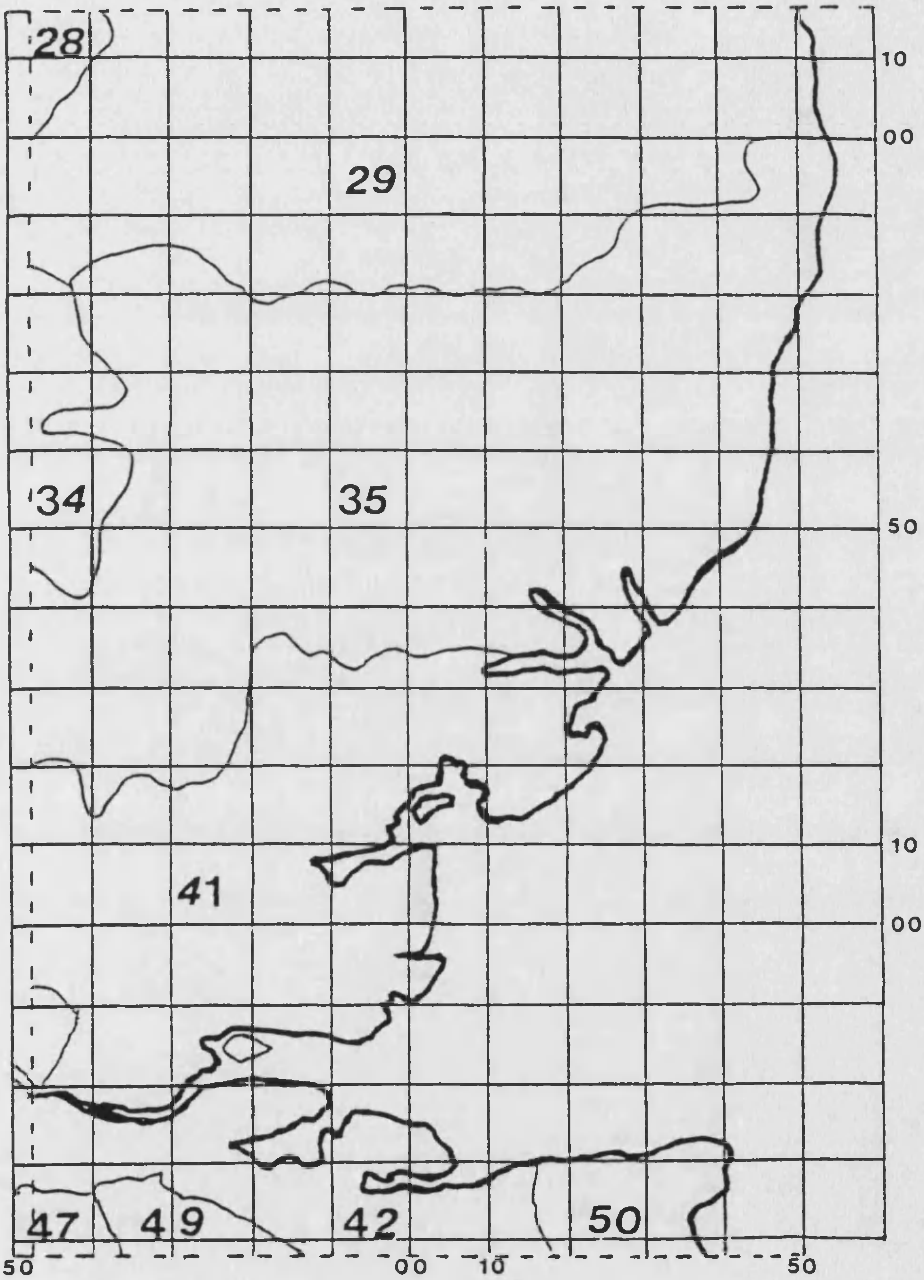


Fig. 9 South Western England

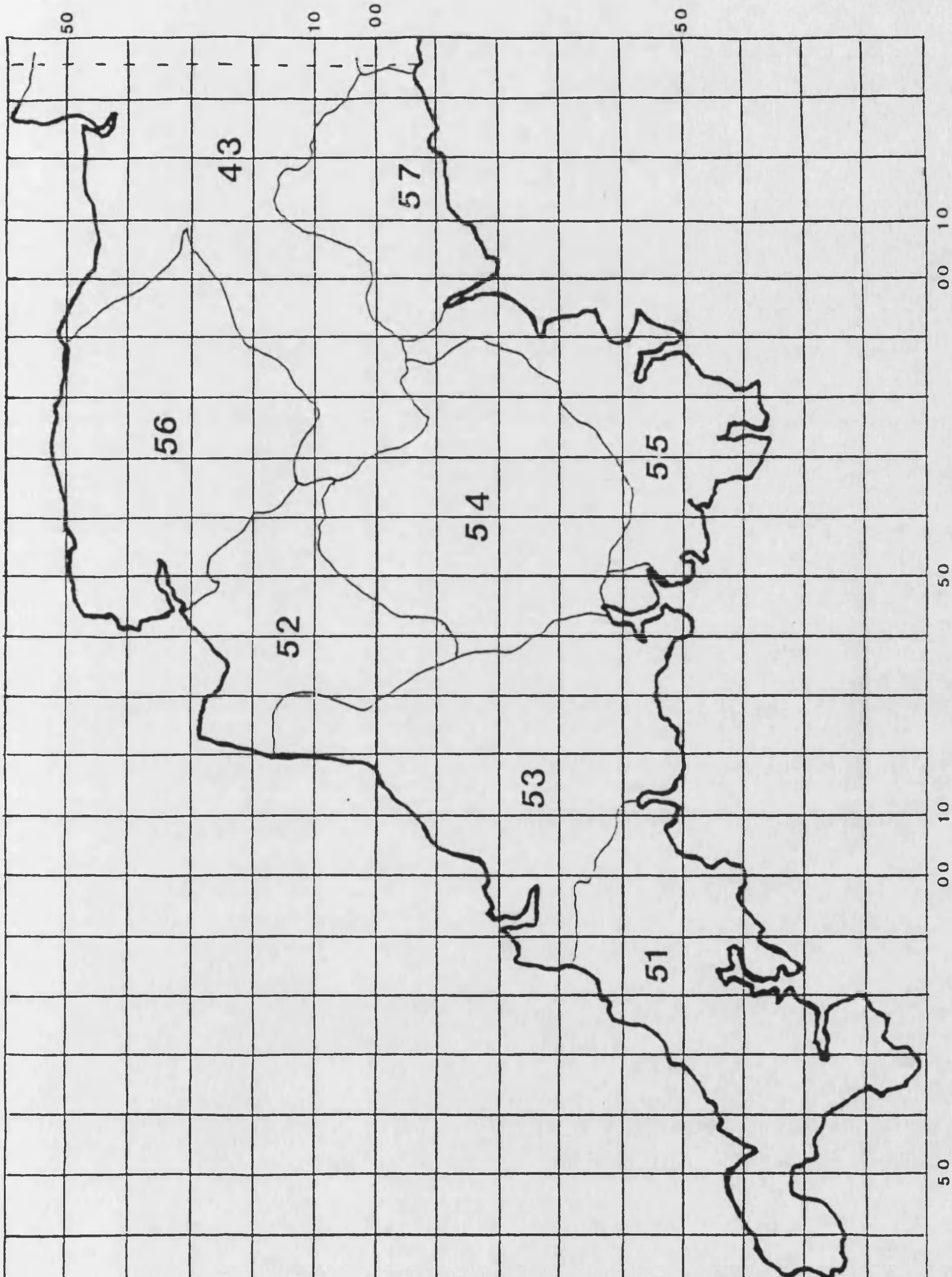


Fig. 10 Southern England

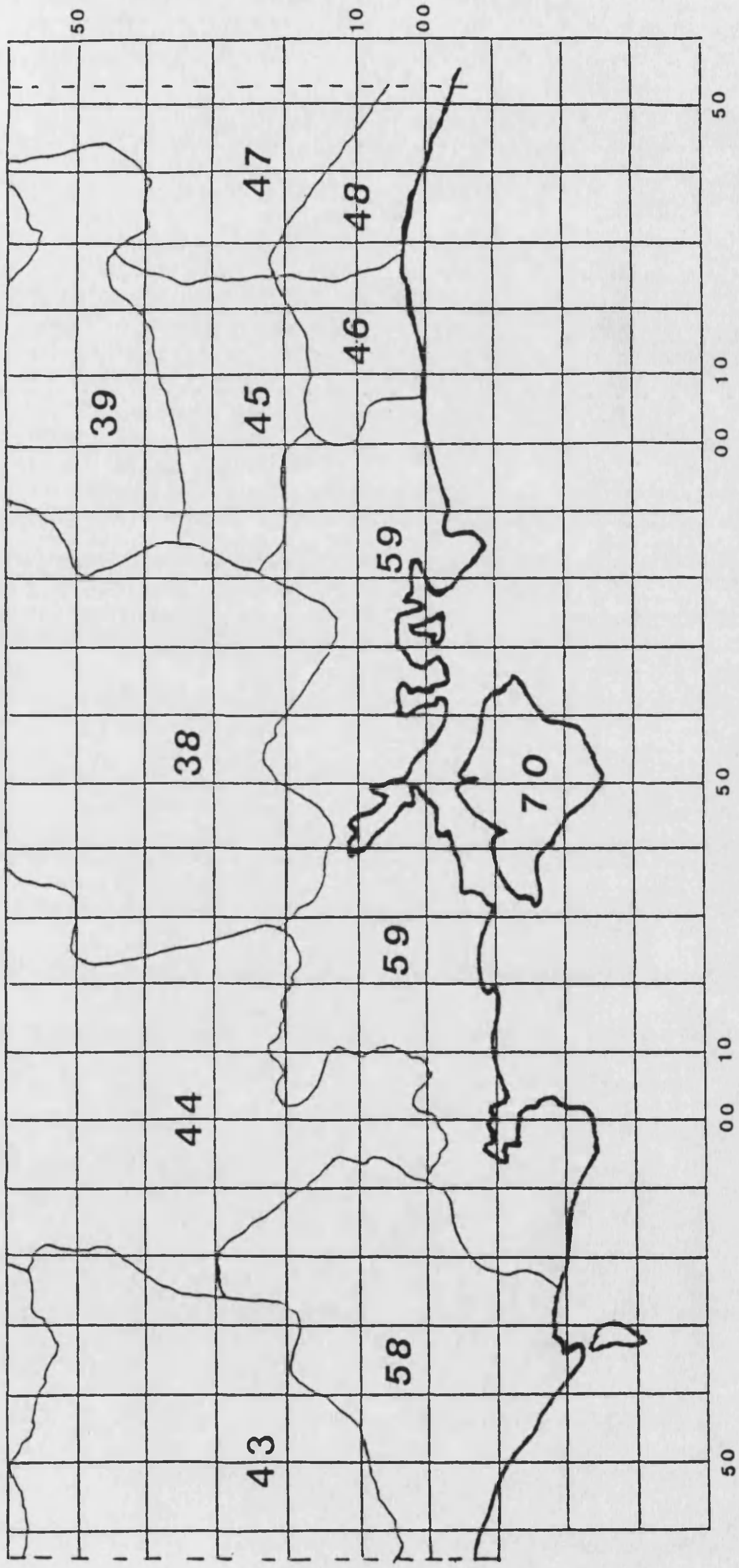
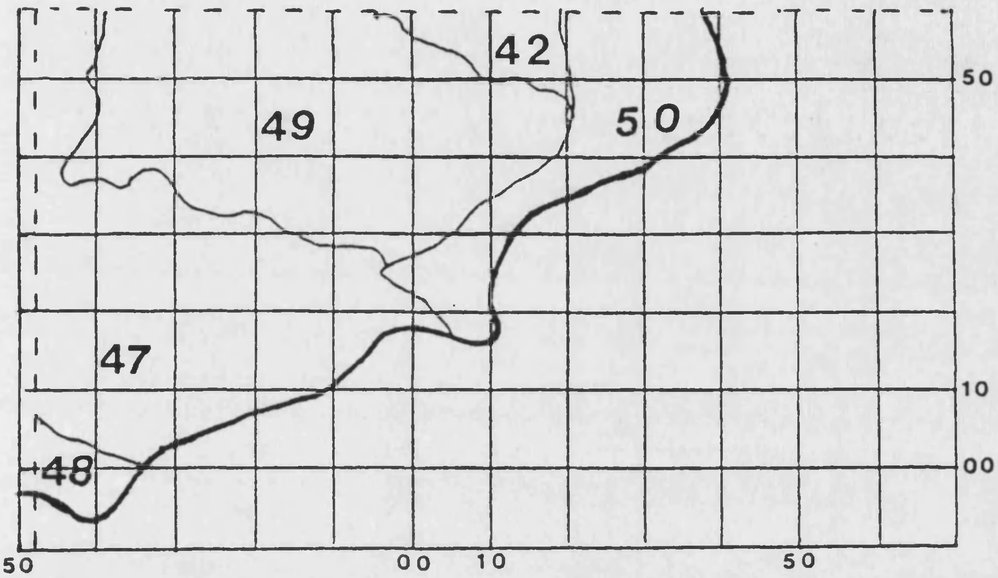


Fig. 11 South Eastern England



APPENDIX B

PRE-RECORDED TOWN DATA

PRE-RECORDED TOWN DATA

Key to abbreviations :

ZONE = AREA CLIMATIC ZONE
SOIL CODE = SOIL SURVEY REFERENCE CODE
FILE CODE = ASSESSMENT MODEL FILE CODE NUMBER
EXPOSURE = PRE-RECORDED EXPOSURE RATING

LOCATION	ZONE	SOIL CODE	FILE CODE	EXPOSURE
ABERDARE	66	713f	230	3
ABERGAVENNY	31	541a	54	2
ABERTILLERY	66	92c	285	3
ABERYSTWYTH	65	541j	63	3
ABINGDON	37	571u	123	2
ACCRINGTON	09	541g	60	2
ALDEBURGH	35	551e	91	2
ALDERSHOT	39	634	178	2
ALDRIDGE	24	712a	216	2
ALFRETON	18	712a	216	2
ALSTON	07	713g	231	3
ALTON	38	511f	39	2
ALTRINCHAM	15	711m	205	2
AMBLE	02	713g	231	2
ANDOVER	38	343h	22	2
APPLEBY	07	711n	206	3
ARKSEY	18	713g	231	2
ARNOLD	18	431	33	2
ARUNDEL	59	814b	258	2
ASHBOURNE	17	811b	242	2
ASHFORD	49	571e	107	2
ASHINGTON	02	711p	208	2

LOCATION	ZONE	SOIL CODE	FILE CODE	EXPOSURE
ASHTON IN MAKERFIELD	09	711m	205	2
ASHTON UNDER LYNE	09	713g	231	2
ASKHAM BRYAN COLLEGE	13	572s	148	2
ATHERTON	09	713g	231	2
AYCLIFFE	06	711p	208	2
AYLESBURY	33	712b	217	3
BACUP	11	541c	56	3
BANBURY	26	544	86	2
BANGOR	61	541r	71	4
BANSTEAD	39	581e	156	2
BARNSLEY	12	541f	59	2
BARNSTAPLE	56	541s	72	3
BARROW IN FURNESS	09	711n	206	2
BARRY	67	712b	217	3
BASILDON	41	712c	218	2
BASINGSTOKE	38	343h	22	2
BATH	36	411a	27	2
BATH UNIVERSITY	36	411a	27	2
BATTLE	47	572i	141	2
BEAUMARIS	60	811b	242	3
BEBINGTON	10	711n	206	2
BECCLES	35	1025	296	2
BEDFORD	34	411c	29	2
BEDWELTY	66	611d	167	3
BEDWORTH	24	711m	205	2
BEESTON	18	561a	99	2
BELLINGHAM	03	711p	208	3

LOCATION	ZONE	SOIL CODE	FILE CODE	EXPOSURE
BENTLEY	18	713	231	2
BERWICK	01	542	84	2
BERWICK UPON TWEED	01	542	84	2
BEVERLEY	14	572o	144	2
BEWDLEY	23	541g	60	2
BEXHILL	47	572i	138	2
BIDEFORD	55	541k	64	3
BINGLEY	12	713g	231	2
BIRKENHEAD	10	711n	206	2
BIRMINGHAM	24	u	297	2
BISHOP AUCKLAND	06	713g	231	2
BISHOP'S CASTLE	22	711a	193	2
BISHOP'S STORTFORD	40	411d	30	2
BLACKBURN	09	713g	231	2
BLACKPOOL	10	711m	205	2
BLANDFORD FORUM	58	511f	39	3
BLAYDON	06	551d	37	2
BLETCHLEY	33	411d	30	3
BLYTH	02	712h	223	2
BOCKING	35	411d	30	2
BODMIN	53	541k	64	3
BOGNOR REGIS	59	841e	271	2
BOLDON	06	511a	34	2
BOLTON	09	713g	231	2
BOOTLE	10	u	297	2
BOSTON	28	812b	247	3
BOURNEMOUTH	59	634	178	2

LOCATION	ZONE	SOIL CODE	FILE CODE	EXPOSURE
BRACKLEY	26	511a	34	2
BRACKNELL	31	643a	182	2
BRAINTREE	41	571y	127	2
BRECON	64	541d	57	3
BREDBURY	09	711m	205	2
BRENTWOOD	41	712c	218	2
BRIDGNORTH	23	551a	87	2
BRIDGWATER	43	814c	259	3
BRIDLINGTON	14	572o	144	2
BRIDPORT	58	541m	66	3
BRIGG	19	813f	254	3
BRIGHOUSE	12	541y	78	2
BRIGHTON	48	343h	22	3
BRISTOL	36	u	297	2
BROADSTAIRS	50	571y	127	3
BROMSGROVE	24	541b	55	2
BROMYARD	30	571b	104	2
BROWNHILLS	24	u	297	2
BUCKINGHAM	33	572q	146	3
BUDE	52	541h	61	3
BURNLEY	11	713g	231	3
BURTON UPON TRENT	16	831c	251	2
BURY	09	u	297	2
BURY ST. EDMUNDS	35	571o	117	2
BUSHEY	39	712c	218	2
BUXTON	11	541p	69	3
CAERNARFON	61	541r	71	4

LOCATION	ZONE	SOIL CODE	FILE CODE	EXPOSURE
CAERPHILLY	66	611d	167	3
CALNE	36	712b	217	2
CAMBERLEY	38	643a	182	2
CAMBORNE	51	541k	64	3
CAMBRIDGE	34	u	297	2
CANNINGTON COLLEGE	43	572f	135	3
CANNOCK	23	711n	206	2
CANTERBURY	42	511f	39	2
CANVEY ISLAND	41	813f	254	2
CARDIFF	67	572m	142	3
CARDIGAN	65	713d	228	3
CARLISLE	04	711n	206	2
CARLTON	18	u	297	2
CARMARTHEN	65	541j	63	3
CASTLEFORD	13	712a	216	2
CASTLETOWN	68	u	297	3
CATERHAM	39	582a	159	2
CHADDERTON	09	u	297	2
CHARD	43	5711	114	3
CHATHAM	42	343h	22	2
CHEADLE	09	u	297	2
CHEADLE	16	u	297	2
CHELMSFORD	41	511j	43	2
CHELTENHAM	36	411b	28	2
CHERTSEY	39	u	297	2
CHESHAM	33	571m	115	3
CHESHUNT	40	813b	250	2

LOCATION	ZONE	SOIL CODE	FILE CODE	EXPOSURE
CHESTER	15	711m	205	2
CHESTERFIELD	11	713a	225	3
CHICHESTER	59	571z	128	2
CHIGWELL	41	712c	218	2
CHIPPENHAM	36	711g	199	2
CHIPPING NORTON	32	343a	15	2
CHORLEY	09	5721	141	2
CHRISTCHURCH	59	571w	125	2
CHURCH STRETTON	22	572m	142	2
CIRENCESTER	32	343d	18	2
CLACTON ON SEA	41	573b	151	2
CLEETHORPES	20	711h	200	3
CLITHEROE	09	713g	231	2
COALVILLE	17	711m	205	2
COLCHESTER	41	573b	151	2
COLNE	09	713g	231	2
COLWYN BAY	15	5721	141	2
CONGLETON	15	711n	206	2
CONSETT	06	713g	231	2
CONWY	61	541h	61	4
CORBY	27	92b	284	2
CORWEN	62	611c	166	3
COVENTRY	24	u	297	2
COWES	70	581b	153	3
CRAWLEY	47	572i	138	2
CREWE	15	712f	221	2
CROMER	29	511d	37	2

LOCATION	ZONE	SOIL CODE	FILE CODE	EXPOSURE
CROOK	06	713g	228	2
CROSBY	10	u	297	2
CUCKFIELD	47	572i	138	2
CWMBRAN	67	541a	54	3
DARLINGTON	06	711p	208	2
DARTFORD	42	571g	109	2
DARTMOUTH	53	541j	63	3
DARWEN	11	541g	60	3
DAVENTRY	26	712g	222	2
DEAL	50	511f	39	3
DENTON	09	5721	141	2
DERBY	17	u	297	2
DEVIZES	44	571h	110	2
DEWSBURY	12	712a	216	2
DISS	29	711r	210	2
DONCASTER	18	u	297	2
DORCHESTER	58	812a	246	3
DORKING	39	571e	107	2
DOUGLAS	68	u	297	3
DOVER	50	343h	22	3
DROITWICH	25	712f	221	3
DROYLSDEN	09	u	297	2
DUDLEY	24	u	297	2
DUKINFIELD	09	u	297	2
DUNSTABLE	34	511e	38	2
DURHAM	06	711p	208	2
DURHAM COLLEGE	06	711p	208	2

LOCATION	ZONE	SOIL CODE	FILE CODE	EXPOSURE
EASTBOURNE	48	342a	11	3
EASTLEIGH	38	711g	199	2
EAST RETFORD	18	821b	262	2
EBBW VALE	66	92c	285	3
ECCLES	09	1021	290	2
EGHAM	39	571w	125	2
ELLESMERE PORT	15	761m	205	2
ELY	34	411d	30	2
EPSOM	39	712c	218	2
ESHER	39	643a	182	2
EVESHAM	25	411b	28	3
EXETER	53	561b	100	3
EXMOUTH	57	572f	135	3
EYE	35	711r	210	2
FAILSWORTH	09	713g	231	2
FALMOUTH	51	541k	64	3
FAREHAM	59	711h	200	2
FARNBOROUGH	38	634	178	2
FARNHAM	39	631d	174	2
FARNWORTH	09	713g	231	2
FAVERSHAM	42	571y	127	2
FFESTINIOG	61	611c	166	4
FLEET	38	643a	182	2
FLEETWOOD	10	361	25	2
FLINT	15	711n	206	2
FOLKESTONE	50	571e	107	3
FORMBY	10	821b	262	2

LOCATION	ZONE	SOIL CODE	FILE CODE	EXPOSURE
FRIMLEY	38	634	178	2
FULWOOD	09	711m	205	2
GAINSBOROUGH	18	711r	210	2
GARFORTH	13	511a	34	2
GATESHEAD	06	u	297	2
GATLEY	09	u	297	2
GILLINGHAM	42	571y	127	2
GLASTONBURY	43	541m	66	3
GLOSSOP	11	713g	231	3
GLOUCESTER	36	411b	28	2
GODALMING	39	571e	107	2
GOOLE	14	532a	52	2
GOSFORTH	02	711p	208	2
GOSPORT	59	571z	128	2
GRANTHAM	19	821b	262	3
GRAVESEND	42	813f	254	2
GREAT YARMOUTH	29	814c	259	2
GRIMSBY	20	711u	213	3
GUILDFORD	39	711h	200	2
HALESOWEN	24	711b	194	2
HALIFAX	12	541f	59	2
HARLECH	61	611c	166	4
HARLOW	40	411d	30	2
HARPENDEN	40	582a	159	2
HARROGATE	12	711p	208	2
HARTLEPOOL	06	711p	209	2
HARWICH	41	573b	151	2

LOCATION	ZONE	SOIL CODE	FILE CODE	EXPOSURE
HASLINGDEN	11	713g	231	3
HASTINGS	47	572i	138	2
HATFIELD	40	571z	128	2
HAVANT	59	711g	199	2
HAVERFORDWEST	65	541j	63	3
HAWES	07	541r	71	3
HEANOR	17	92c	285	2
HEBBURN	06	u	297	2
HEDON	14	814c	259	2
HELSTON	51	541j	63	3
HEMEL HEMPSTEAD	40	582c	161	2
HEREFORD	30	571b	104	2
HERNE BAY	50	711h	200	3
HERTFORD	40	411d	30	2
HEXHAM	03	713g	231	3
HEYWOOD	09	821b	262	2
HINCKLEY	26	5721	141	2
HINDLEY	09	713g	231	2
HITCHING	34	u	297	2
HODDESDON	40	813b	250	2
HOLSWORTHY	55	541h	61	3
HONITON	57	541w	76	3
HORSHAM	45	541m	66	2
HOUGHTON LE SPRING	06	711p	208	2
HOVE	48	343h	22	3
HOYLAKE	10	361	25	2
HUCKNALL	18	511a	34	2

LOCATION	ZONE	SOIL CODE	FILE CODE	EXPOSURE
HUDDERSFIELD	11	u	297	3
HULL	14	813f	54	2
HUNGERFORD	37	581b	153	2
HUNTINGDON	34	411d	30	2
HYDE	09	811a	241	2
HYTHE	50	361	25	3
ILFRACOMBE	52	541j	63	3
ILKESTON	17	712a	216	2
ILKLEY	12	712a	216	2
IPSWICH	35	571x	126	2
IRLAM	09	1021	290	2
JARROW	06	u	297	2
KEIGHLEY	11	713g	231	3
KENDAL	09	541j	63	2
KETTERING	26	544	86	2
KIDDERMINSTER	23	551a	87	2
KIDSGROVE	16	92c	285	2
KINGSBRIDGE	53	541a	54	3
KINGS LYNN	28	532a	52	3
KINGSTON UPON HULL	14	813f	254	2
KINGSWOOD	36	712A	216	2
KIRKBY	10	641a	179	2
KIRKBY IN ASHFIELD	18	511a	34	2
KNUTSFORD	15	821b	262	2
LAMPETER	65	541j	63	3
LAMPLUGH	04	713f	230	2
LANCASTER	09	713f	230	2

LOCATION	ZONE	SOIL CODE	FILE CODE	EXPOSURE
LAUNCESTON	53	541k	64	3
LAXEY	68	u	297	3
LEAMINGTON SPA	25	541r	71	4
LEATHERHEAD	39	343g	21	2
LEEDS	12	u	297	2
LEICESTER	26	u	297	2
LEOMINSTER	30	811b	242	2
LETCHWORTH	34	411d	30	2
LEWES	48	342a	11	3
LEYLAND	09	711m	205	2
LICHFIELD	24	551a	87	2
LINCOLN	19	343a	15	3
LISKEARD	53	541j	63	3
LITHERLAND	10	u	297	2
LIVERPOOL	10	u	297	2
LLANDOVERY	65	561b	100	3
LLANDRINDOD WELLS	64	713d	231	3
LLANELLI	65	811e	245	3
LLANGEFNI	60	541z	79	3
LLANIDLOES	63	713g	231	3
LONDON	39	u	297	2
LONG EATON	18	561a	99	2
LOUGHBOROUGH	17	813c	251	2
LOUTH	20	711m	205	3
LOWESTOFT	35	511f	39	2
LUDLOW	22	571b	104	2
LUTON	34	582a	159	2

LOCATION	ZONE	SOIL CODE	FILE CODE	EXPOSURE
LYDD	50	361	25	3
LYME REGIS	57	411b	28	3
LYMINGTON	59	571s	121	2
LYTHAM ST. ANNES	10	821b	262	2
MACCLESFIELD	15	541r	71	2
MACHYNLLETH	61	611c	166	4
MAESTEG	66	654c	192	3
MAIDENHEAD	39	571j	112	2
MAIDSTONE	49	571c	105	2
MALDON	41	712c	218	2
MALMESBURY	36	711g	199	2
MALVERN	30	u	297	2
MANCHESTER	09	u	297	2
MANGOTSFIELD	36	712a	216	2
MANSFIELD	18	572a	130	2
MARCH	28	851a	272	3
MARGATE	50	571y	127	3
MARKET DRAYTON	16	541b	55	2
MARLBOROUGH	44	581d	155	2
MARPLE	09	713g	231	2
MATLOCK	11	541p	69	3
MEALSGATE	04	713g	231	2
MERRIST WOOD COLLEGE	39	643a	182	2
MERTHYR TYDFIL	66	721c	238	3
MIDDLESBOROUGH	06	711p	208	2
MIDHURST	45	631c	173	2
MILTON KEYNES	33	411d	30	3

LOCATION	ZONE	SOIL CODE	FILE CODE	EXPOSURE
MINEHEAD	52	541g	60	3
MOLD	15	541r	71	2
MONMOUTH	31	561d	102	2
MONTGOMERY	21	713d	228	2
MORECAMBE	09	851b	273	2
MORLEY	12	541f	59	2
MORPETH	02	711p	208	2
MOSSLEY	09	541g	60	2
MOUNTAIN ASH	66	654c	192	3
NANTWICH	15	821b	262	2
NEATH	65	713f	230	3
NELSON	09	541g	60	2
NEWARK ON TRENT	18	831c	265	2
NEWBURN	02	551d	90	2
NEWBURY	37	711g	199	2
NEWCASTLE UNDER LYNE	16	u	297	2
NEWCASTLE UNDER LYME	16	u	297	2
NEWCASTLE UPON TYNE	02	u	297	2
NEWPORT	31	551d	90	2
NEWQUAY	51	541k	64	3
NEW ROMNEY	50	532b	53	3
NEWTON LE WILLOWS	10	711m	205	2
NORTHAMPTON	26	544	86	2
NORTHFLEET	42	813f	254	2
NORTON	14	u	297	2
NORWICH	29	572n	143	2
NOTTINGHAM	18	u	297	2

LOCATION	ZONE	SOIL CODE	FILE CODE	EXPOSURE
NUNEATON	24	572f	135	2
OAKHAM	27	544	86	2
OGMORE	67	541p	69	3
OKEHAMPTON	55	541j	63	3
OLDHAM	09	u	297	2
ONCHAN	68	u	297	3
ORMSKIRK	10	711o	207	2
OSSETT	12	712a	216	2
OXFORD	37	711f	198	2
PEEL	68	u	297	3
PEMBROKE	65	541a	54	3
PENARTH	67	712b	217	3
PENRITH	07	541c	56	3
PENRYN	51	541k	64	3
PENZANCE	51	541k	64	3
PERSHORE COLLEGE	25	572t	149	4
PETERBOROUGH	34	841d	270	2
PETERLEE	06	711m	205	2
PICKERING	08	541f	59	3
PLYMOUTH	55	541j	63	3
PONTEFRACT	13	511a	54	2
PONTYPOOL	67	541d	57	3
PONTYPRIDD	67	611d	167	3
POOLE	59	641b	180	2
PORTSMOUTH	59	u	297	2
PORT TALBOT	66	611d	167	3
POTTERS BAR	40	712c	218	2

LOCATION	ZONE	SOIL CODE	FILE CODE	EXPOSURE
PRESTON	09	711m	205	2
PRESTWICH	09	551d	90	2
PUDSEY	12	u	297	2
PWLLHELI	60	811d	244	3
QUEENBOROUGH	42	813f	254	2
RADCLIFFE	09	713g	231	2
RAMSEY	68	u	297	3
RAMSGATE	50	571y	127	3
RAWTENSTALL	11	541g	60	3
RAYLEIGH	41	712c	218	2
READING	39	841b	268	2
READING UNIVERSITY	39	841b	268	2
REASEHEATH COLLEGE	15	821b	262	2
REDDITCH	24	711c	195	2
REIGATE	39	711e	197	2
RHONDDA	66	721c	238	3
RHYL	15	361	25	2
RICHMOND	05	551d	90	3
RIPON	13	542	84	2
RISCA	67	571b	104	3
ROCHDALE	09	u	297	2
ROCHESTER	42	571g	109	2
ROMSEY	38	571z	128	2
ROSS ON WYE	30	541c	56	2
ROTHERHAM	12	712a	216	2
ROTHWELL	13	712a	216	2
ROYSTON	34	342a	11	2

LOCATION	ZONE	SOIL CODE	FILE CODE	EXPOSURE
RUGBY	24	543	85	2
RUGELEY	16	541r	71	2
RUNCORN	10	u	297	2
RYDE	59	711h	200	2
RYE	47	814b	258	2
SAFFRON WALDEN	35	511e	38	2
SALCOMBE	53	541a	54	3
SALE	09	u	297	2
SALFORD	09	u	297	2
SALISBURY	44	812a	246	2
SALTASH	53	541n	67	3
SANDOWN	70	572h	137	3
SANDWICH	50	814c	259	3
SCARBOROUGH	08	711m	205	3
SCUNTHORPE	19	821b	61	3
SEAHAM	06	711p	208	2
SEATON	02	711p	208	2
SELBY	13	821a	261	2
SEVENOAKS	47	581g	158	2
SHAFTESBURY	58	5711	114	3
SHANKLIN	70	571h	110	3
SHEFFIELD	11	712a	216	3
SHIPLEY	12	541f	59	2
SHOREHAM	46	511g	40	2
SHREWSBURY	21	541r	71	2
SIDMOUTH	57	572f	135	3
SITTINGBOURNE	42	571y	127	2

LOCATION	ZONE	SOIL CODE	FILE CODE	EXPOSURE
SKEGNESS	20	813g	255	3
SKELMERSDALE	10	641a	179	2
SKIPTON	09	713f	230	2
SLEAFORD	19	512a	44	3
SLOUGH	39	714d	235	2
SOLIHULL	24	714b	233	2
SOUTH MOLTON	56	541k	64	3
SOUTHAMPTON	59	u	297	2
SOUTHEND ON SEA	41	571z	128	2
SOUTHPORT	10	361	25	2
SOUTHWOLD	35	551g	93	2
SPALDING	28	812b	47	3
STAFFORD	16	813a	49	2
STAINES	39	u	297	2
STALYBRIDGE	09	651a	186	2
STAMFORD	27	343c	17	2
STANHOPE	05	713g	231	3
STANLEY	06	713g	231	2
STAPLEFORD	18	712a	216	2
STEVENAGE	34	582c	161	2
ST. ALBANS	40	582d	162	2
ST. AUSTELL	51	541k	64	3
ST. HELENS	10	641a	179	2
ST. IVES	51	541n	67	3
STOCKPORT	09	711m	205	2
STOCKTON ON TEES	06	711m	205	2
STOKE ON TRENT	16	u	297	2

LOCATION	ZONE	SOIL CODE	FILE CODE	EXPOSURE
STONE	16	572f	135	2
STOURBRIDGE	24	511a	34	2
STRATFORD UPON AVON	25	541r	71	5
STRETFORD	09	u	297	2
SUDBURY	35	571o	117	2
SUNDERLAND	06	u	297	2
SUTTON COALFIELD	24	711n	206	2
SUTTON IN ASHFIELD	18	511a	34	2
SWADLINCOTE	17	713a	225	2
SWAFFHAM	29	554b	97	2
SWANSEA	65	u	297	3
SWINDON	36	712b	217	2
SWINTON	09	u	297	2
TAMWORTH	24	811a	241	2
TAUNTON	43	431	33	3
TAVISTOCK	54	541j	63	3
TEESIDE	06	712f	221	2
TELFORD	23	92c	285	2
TENBY	65	541h	61	3
TENTERDEN	49	711e	197	2
TEWKESBURY	36	813b	250	2
THETFORD	29	521	51	2
THIRSK	08	551d	90	3
THORNTON	10	711m	205	2
TIVERTON	43	541b	55	3
TODMORDEN	11	651a	186	3
TONBRIDGE	47	813d	252	2

LOCATION	ZONE	SOIL CODE	FILE CODE	EXPOSURE
TORBAY	53	541e	58	3
TORQUAY	53	541e	58	3
TOTNES	53	541n	67	3
TREGARON	63	541v	75	3
TRESCO	69	u	297	3
TRURO	51	541j	63	3
TUNBRIDGE WELLS	49	572i	138	2
TYLDESLEY	09	713g	231	2
TYNEMOUTH	02	u	297	2
TYWYN	15	541v	75	2
URMSTON	09	811b	242	2
UTTOXETER	16	572f	135	2
VENTNOR	70	571h	110	3
WAKEFIELD	12	712a	216	2
WALLASEY	10	361	25	2
WALLINGFORD	37	571v	124	2
WALLSEND	02	u	297	2
WALSALL	24	712a	216	2
WALTON	04	551d	90	2
WALTON LE DALE	09	711m	205	2
WAREHAM	59	641b	180	2
WARLEY	24	u	297	2
WARRINGTON	10	711m	205	2
WARWICK	25	711c	195	4
WASHINGTON	06	u	297	2
WATFORD	33	581b	153	3
WELLINGBOROUGH	27	511b	35	2

LOCATION	ZONE	SOIL CODE	FILE CODE	EXPOSURE
WELSHPOOL	21	541j	63	2
WELWYN GARDEN CITY	40	571y	127	2
WEST BRIDGFORD	18	572g	136	2
WEST BROMWICH	24	u	297	2
WESTON SUPER MARE	36	814c	259	2
WETHERBY	13	511a	34	2
WEYMOUTH	58	712b	217	3
WHITBY	08	711m	205	3
WHITCHURCH	21	541r	71	2
WHITEHAVEN	04	713g	231	2
WHITLEY BAY	02	713g	231	2
WHITSTABLE	42	712c	205	2
WIDNES	10	711m	218	2
WIGAN	09	u	297	2
WIGSTON	26	712g	222	2
WILLINGTON	06	711p	208	2
WILMSLOW	15	711m	205	2
WILTON	44	581d	155	2
WINCHESTER	38	343h	22	2
WINDERMERE	07	541j	63	3
WINDSOR	39	711h	200	2
WINSFORD	15	711m	205	2
WIRRAL	10	u	297	2
WISBECH	28	812b	247	3
WISLEY GARDENS	39	813d	252	2
WOKING	39	813d	252	2
WOKINGHAM	39	711h	200	2

LOCATION	ZONE	SOIL CODE	FILE CODE	EXPOSURE
WOLVERHAMPTON	24	u	297	2
WOODSTOCK	32	343a	15	2
WOOLER	03	561c	101	3
WORCESTER	25	572f	135	4
WORKINGTON	04	713g	231	2
WORKSOP	18	551b	88	2
WORTHING	46	511f	39	2
WREXHAM	15	711m	205	2
WRITTLE COLLEGE	41	511j	43	2
YARMOUTH	70	813d	252	3
YEOVIL	43	572i	138	3
YORK	13	712i	224	2

APPENDIX C

TAXA CONSIDERED TO BE SUSCEPTIBLE TO DAMAGE IN EXTREME WINTER CONDITIONS

PLANTS CONSIDERED SUSCEPTIBLE TO DAMAGE BY FROST

ABELIA CHINENSIS

ABELIA FLORIBUNDA

ABELIA SCHUMANNII

ABIES OAXACANA

ABIES REGLIOSA

ABIES VEJARI

ABUTILON 'ASHFORD RED'

ABUTILON MEGAPOTAMICUM

ABUTILON MEGAPOTANICUM 'VARIEGATUM'

ABUTILON OCHSENII

ABUTILON VITIFOLIUM

ABUTILON VITIFOLIUM 'ALBUM'

ABUTILON VITIFOLIUM 'VERONICA TENNANT'

ABUTILON X MILLERI

ABUTILON X MILLERI 'VARIEGATUM'

ABUTILON X SUNTENSE

ABUTILON X SUNTENSE 'JERMYNS'

ACACIA 'EXETER HYBRID'

ACACIA ARMATA

ACACIA BAILEYANA

ACACIA DEALBATA

ACACIA DIFFUSA

ACACIA LONGIFOLIA

ACACIA LONGIFOLIA SOPHORAE

ACACIA MELANOXYLON

ACACIA MUCRONATA

ACACIA PENDULA

ACACIA RICEANA

ACER CAMPBELLII

ACER FLABELLATUM

ACER FLABELLATUM YUNNANENSE

ACER HOOKERI

ACER LAEVIGATUM

ACER OBLONGUM

ACER OBLONGUM CONCOLOR

ACER PAXII

ACER WARDII

ACER X OSMASTONII

ACRADENIA FRANKLINIAE

ACTINIDIA CORIACEA

ADENOCARPUS ANAGYRIFOLIUS LEIOCARPUS

ADENOCARPUS FOLIOSUS

AGATHIS AUSTRALIS

ALBIZIA LOPHANTHA

AMICIA ZYGOMERIS

ANAGYRIS FOETIDA

ANOPTERUS GLANDULOSUS

ANTHYLLIS BARBA-JOVIS

ARAUJIA SERICOFERA

ARBUTUS ANDRACHNE

ARBUTUS MENZIESII

ARBUTUS X ANDRACHNOIDES

ARCTOSTAPHYLOS TOMENTOSA

ARDISIA JAPONICA

ARISTOLOCHIA SEMPERVIRENS

ARISTOTELIA CHILENSIS

ARISTOTELIA CHILENSIS 'VARIEGATA'

ARISTOTELIA SERRATA

ARTEMISIA ARBORESCENS

ASTERANTHERA OVATA

ATHROTAXIS SELAGINOIDES

AZARA DENTATA

AZARA INTEGRIFOLIA

AZARA INTEGRIFOLIA 'VARIEGATA'

AZARA INTEGRIFOLIA BROWNEAE

AZARA LANCEOLATA

AZARA MICROPHYLLA

AZARA MICROPHYLLA 'VARIEGATA'

AZARA PETIOLARIS

AZARA SERRATA

BANKSIA INTEGRIFOLIA

BANKSIA MARGINATA

BAROSMA PULCHELLA

BAUERA RUBIOIDES

BERBERIDOPSIS CORALLINA

BERBERIS ASIATICA

BERBERIS COMBERI

BERBERIS CRISPA

BERBERIS INCRASSATA

BERBERIS LEVIS

BERBERIS SUBLEVIS

BESCHORNERIA YUCCOIDES

BETULA CYLINDROSTACHYA

BIGNONIA CAPRIOLATA

BILLARDIERA LONGIFOLIA

BILLARDIERA LONGIFOLIA 'FRUCTO-ALBO'

BOUVARDIA TRIPHYLLA

BOWKERIA GERARDIANA

BRACHYGLOTTIS REPANDA

BRACHYGLOTTIS REPANDA 'PURPUREA'

BUDDLEIA ASIATICA

BUDDLEIA AURICULATA

BUDDLEIA CANDIDA

BUDDLEIA FARRERI

BUDDLEIA FORRESTII

BUDDLEIA MADAGASCARIENSIS

BUDDLEIA OFFICINALIS

BUDDLEIA PTEROCAULIS

BUDDLEIA SALVIIFOLIA

BUDDLEIA X LEWISIANA 'MARGARET PIKE'

BURSARIA SPINOSA

CAESALPINIA GILLIESII

CAESALPINIA TINCTORA

CALCEOLARIA INTEGRIFOLIA

CALCEOLARIA INTEGRIFOLIA ANGUSTIFOLIA

CALLISTEMON CITRINUS

CALLISTEMON CITRINUS 'SPLENDENS'

CALLISTEMON LINEARIS

CALLISTEMON PALLIDUS

CALLISTEMON RIGIDUS

CALLISTEMON SALIGNUS

CALLISTEMON SPECIOSUS

CALLITRIS OBLONGA

CALLITRIS RHOMBOIDEA

CALOCEDRUS FORMOSANA

CALOCEDRUS MACROLEPIS

CAMELLIA 'INAMORATA'

CAMELLIA DRUPIFERA

CAMELLIA GRANTHAMIANA

CAMELLIA HONGKONGENSIS

CAMELLIA JAPONICA 'MATHOTIANA ALBA'

CAMELLIA JAPONICA 'MRS. D.W. DAVIS'

CAMELLIA OLEIFERA

CAMELLIA OLEIFERA 'JUANE'

CAMELLIA RETICULATA 'BUDDHA'

CAMELLIA RETICULATA 'BUTTERFLY WINGS'

CAMELLIA RETICULATA 'CAPTAIN RAWES'

CAMELLIA RETICULATA 'CRIMSON ROBE'

CAMELLIA RETICULATA 'LION HEAD'

CAMELLIA RETICULATA 'NOBLE PEARL'

CAMELLIA RETICULATA 'PROFESSOR TSAI'

CAMELLIA RETICULATA 'PURPLE GOWN'

CAMELLIA RETICULATA 'ROBERT FORTUNE'

CAMELLIA RETICULATA 'SHOT SILK'

CAMELLIA SALUENSIS

CAMELLIA SINENSIS

CAMELLIA TALIENSIS

CAMELLIA TSAII

CANTUA BUXIFOLIA

CARMICHAELIA AUSTRALIS

CARMICHAELIA FLAGELLIFORMIS

CARMICHAELIA WILLIAMSII

CARPODETUS SERRATUS

CASSIA CORYMBOSA

CASSIA OBTUSA

CASUARINA NANA

CEANOTHUS 'A.T. JOHNSON'

CEANOTHUS 'BURKWOODII'

CEANOTHUS 'CASCADE'

CEANOTHUS 'DIGNITY'

CEANOTHUS 'EDINBURGH'

CEANOTHUS 'INDIGO'

CEANOTHUS 'ITALIAN SKIES'

CEANOTHUS ARBOREUS

CEANOTHUS ARBOREUS 'TREWITHEN BLUE'

CEANOTHUS CAERULEUS

CEANOTHUS CRASSIFOLIUS

CEANOTHUS CYANEUS

CEANOTHUS DENTATUS

CEANOTHUS DIVERGENS

CEANOTHUS FOLIOSUS

CEANOTHUS GLORIOSUS

CEANOTHUS GLORIOSUS EXALTATUS

CEANOTHUS IMPRESSUS

CEANOTHUS INTEGERRIMUS

CEANOTHUS JEPSONII

CEANOTHUS MEGACARPUS

CEANOTHUS PAPILLOSUS

CEANOTHUS PAPILLOSUS ROWEANUS

CEANOTHUS PURPUREUS

CEANOTHUS RIGIDUS

CEANOTHUS RIGIDUS PALLENS

CEANOTHUS SOREDIATUS

CEANOTHUS SPINOSUS

CEANOTHUS VERRUCOSUS

CEANOTHUS X LOBBIANUS

CEANOTHUS X LOBBIANUS 'RUSSELLIANUS'

CESTRUM 'NEWELLII'

CESTRUM AURANTIACUM

CESTRUM ELEGANS

CESTRUM PARQUI

CHAMAEROPS HUMILIS

CHLORANTHUS BRACHYSTACHYS

CINNAMOMUM CAMPHORA

CINNAMOMUM GLANDULIFERUM

CISSUS ANTARTICA

CISSUS STRIATA

CISTUS 'ELMA'

CISTUS LADANIFER

CISTUS LADANIFER 'ALBIFLORUS'

CISTUS MONSPELIENSIS

CISTUS PALHINAE

CISTUS PARVIFLORUS

CISTUS SALVIIFOLIUS

CISTUS SALVIIFOLIUS 'PROSTRATUS'

CISTUS SYMPHITIFOLIUS

CISTUS X AGUILARI

CISTUS X AGUILARI 'MACULATUS'

CISTUS X OBTUSIFOLIUS

CISTUS X PULVERULENTUS

CISTUS X PURPUREUS

CISTUS X SKANBERGII

CITHAREXYLUM SPICATUM

CITRUS 'MEYER'S LEMON'

CITRUS ICHANGENSIS

CLEMATIS ARMANDII

CLEMATIS ARMANDII 'APPLE BLOSSOM'

CLEMATIS BRACHIATA

CLEMATIS FINETIANA

CLEMATIS MEYENIANA

CLEMATIS NAPAULENSIS

CLEMATIS PANICULATA

CLEMATIS PANICULATA 'LOBATA'

CLEMATIS PHLEBANTHA

CLEMATIS TEXENSIS

CLEMATIS UNCINATA

CLETHRA ARBOREA

CLETHRA MONOSTACHYA

CLIANTHUS PUNICEUS

CLIANTHUS PUNICEUS 'ALBUS'

CNEORUM TRICOCCON

COLLETIA INFAUSTA

COLQUHOUNIA COCCINEA

COLQUHOUNIA COCCINEA MOLLIS

COPROSMA LUCIDA

COPROSMA X CUNNINGHAMII

CORDYLINE AUSTRALIS

CORDYLINE AUSTRALIS 'ATROPURPUREA'

CORDYLINE INDIVISA

CORIARIA NAPALENSIS

CORNUS CAPITATA

CORNUS CHINENSIS

CORNUS CONTROVERSA

CORNUS OBLONGA

COROKIA BUDDLEIOIDES

COROKIA BUDDLEIOIDES LINEARIS

COROKIA MACROCARPA

CORONILLA GLAUCA

CORONILLA GLAUCA 'VARIEGATA'

CORONILLA VALENTINA

CORREA ALBA

CORREA BACKHOUSIANA

CORREA DECUMBENS

CORREA PULCHELLA

CORREA X HARRISII

CRINODENDRON HOOKERANUM

CRINODENDRON PATAGUA

CUDRANIA TRICUSPIDATA

CUNNINGHAMIA KONISHII

CUPRESSUS CACHMERIANA

CUPRESSUS GUADALUPENSIS

CUPRESSUS LUSITANICA

CUPRESSUS LUSITANICA 'BENTHAMII'

CUPRESSUS LUSITANICA 'GLAUCA PENDULA'

CUPRESSUS SARGENTII

CYATHODES ROBUSTA

CYTISUS 'PORLOCK'

CYTISUS MONSPESSULANUS

DABOECIA AZORICA

DACRYDIUM BIFORME

DACRYDIUM COLENSOI

DACRYDIUM CUPRESSINUM

DACRYDIUM FRANKLINII

DACRYDIUM LAXIFOLIUM

DAMNACANTHUS INDICUS

DANKSIA SERRATA

DAPHNE JASMINEA

DAPHNE PAPYRACEA

DATURA SANGUINEA

DATURA SUAVEOLANS

DEBREGEASIA LONGIFOLIA

DENDROMECON RIGIDA

DESFONTAINEA SPINOSA

DESFONTAINEA SPINOSA 'HAROLD COMBER'

DESMODIUM PRAESTANS

DICHOTOMANTHES TRISTANIICARPA

DRIMYS LANCEOLATA

DRIMYS WINTERI

DRIMYS WINTERI ANDINA

ECCREMOCARPUS SCABER

ELAEOCARPUS CYANEUS

ELAEOCARPUS DENTATUS

ELYTROPUS CHILENSIS

EMBOTHRIUM COCCINEUM 'LONGIFOLIUM'

EMBOTHRIUM COCCINEUM LANCEOLATUM

ENTELEA ARBORESCENS

ERICA PAGEANA

ERICA UMBELLATA

ERYTHRINA CRISTA-GALLI

ESCALLONIA 'IVEYI'

ESCALLONIA LAEVIS

ESCALLONIA REVOLUTA

EUCALYPTUS CINEREA

EUCALYPTUS CITRIODORA

EUCALYPTUS CORDATA

EUCALYPTUS FICIFOLIA

EUCALYPTUS GLOBULUS

EUCALYPTUS PERRINIANA

EUCALYPTUS PULVERULENTA

EUCALYPTUS SALICIFOLIA

EUCRYPHIA CORDIFOLIA

EUCRYPHIA CORDIFOLIA X LUCIDA

EUCRYPHIA MILLIGANII

EUCRYPHIA MOOREI

EUCRYPHIA X HILLIERI

EUCRYPHIA X HILLIERI 'WINTON'

EUGENIA GUAYARILLO

EUGENIA MYRTIFOLIA

EUGENIA PUNGENS

EUONYMUS FRIGIDUS

EUONYMUS ILICIFOLIUS

EUPATORIUM LIGUSTRINUM

EURYOPS PECTINATUS

EURYOPS VIRGINEUS

EURYA EMARGINATA 'MICROPHYLLA'

FABIANA IMBRICATA

FABIANA INBRICATA VIOLACEA

FASCICULARIA BICOLOR

FEIJOA SELLOWIANA

FEIJOA SELLOWIANA 'VARIEGATA'

FENDLERA WRIGHTII

FICUS CARICA

FICUS NIPPONICA

FICUS NIPPONICA 'VARIEGATA'

FICUS PUMILA

FICUS PUMILA 'MINIMA'

FIRMIANA SIMPLEX

FITZROYA CUPRESSOIDES

FOKIENIA HODGINSII

FORTUNELLA JAPONICA

FRANKLINIA ALATAMAHA

FRAXINUS DIPELTALA

FRAXINUS FLORIBUNDA

FRAXINUS GRIFFITHII

FREMONTODENDRON CALIFORNICUM

FREMONTODENDRON MEXICANUM

FREYLINIA LANCEOLATA

FUCHSIA 'BRILLIANT'

FUCHSIA 'DISPLAY'

FUCHSIA 'ELSA'

FUCHSIA 'MADAME CORNELISSEN'

FUCHSIA 'REFLEXA'

FUCHSIA EXCORTICATA

FUCHSIA MAGELLANICA

FUCHSIA MAGELLANICA 'VARIEGATA'

FUCHSIA PROCUMBENS

FUCHSIA X BACILLARIS

FUCHSIA X BACILLARIS 'COTTINGHAMII'

GARRYA FLAVESCENS

GARRYA FREMONTII

GARRYA LAURIFOLIA MACROPHYLLA

GAULTHERIA NUMMULARIOIDES

GELSEMIUM SEMPERVIRENS

GENISTA EPHEDROIDES

GENISTA FALCATA

GENISTA FASSELATA

GENISTA MONOSPERMA

GEVUINA AVELLANA

GLYPTOSTROBUS LINEATUS

GORDONIA AXILLARIS

GORDONIA CHRYSANDRA

GORDONIA LASIANTHUS

GREVILLEA ALPINA

GREVILLEA GLABRATA

GREVILLEA ORNITHOPODA

GREVILLEA ROSMARINIFOLIA

GREVILLEA SULPHUREA

GREVILLEA X SEMPERFLORENS

GREWIA OCCIDENTALIS

GRISELINIA LITTORALIS

GRISELINIA LITTORALIS 'DIXON'S CREAM'

GRISELINIA LITTORALIS 'VARIEGATA'

GRISELINIA LUCIDA

HAKEA MICROCARPA

HAKEA SERICEA

HALIMIUM ATRIPLICIFOLIUM

HALIMIUM HALIMIFOLIUM

HEBE 'ALICIA AMHERST'

HEBE 'BOWLES HYBRID'

HEBE 'CARNEA'

HEBE 'ETTRICK SHEPHERD'

HEBE 'GLORIOSA'

HEBE 'GREAT ORME'

HEBE 'HEADFORTII'

HEBE 'HIELAN LASSIE'

HEBE 'LA SEDUISANTE'

HEBE 'MIDSUMMER BEAUTY'

HEBE 'MRS. E. TENNANT'

HEBE 'MRS. WINDER'

HEBE 'PURPLE QUEEN'

HEBE 'SIMON DELAUX'

HEBE 'WAIKIKI'

HEBE ARMSTRONGII

HEBE COOKIANA

HEBE DIEFFENBACHII

HEBE LAVAUDIANA

HEBE MACRANTHA

HEBE PARVIFLORA

HEBE PARVIFLORA ANGUSTIFOLIA

HEBE X ANDERSONII 'VARIEGATA'

HELICHRYSUM PETIOLATUM

HELICHRYSUM PLICATUM

HELICHRYSUM SCUTELLIFOLIUM

HELICHRYSUM SELAGO

HELICHRYSUM SELAGO 'MAJOR'

HELICHRYSUM STOEKAS

HETEROMELES ARBUTIFOLIA

HIBISCUS HAMABO

HOHERIA ANGUSTIFOLIA

HOHERIA POPULINEA

HOHERIA POPULINEA 'FOLIIS PURPUREIS'

HOHERIA POPULINEA 'VARIEGATA'

HOHERIA SEXSTYLOSA

HYDRANGEA CHINENSIS

HYPERICUM BALEARICUM

HYPERICUM CHINENSE

HYPERICUM LESCHENAULTII

ILEX CILIOSPINOSA

ILEX CORALLINA

ILEX CORALLINA PUBESCENS

ILEX FRAGILIS

ILEX FRANCHETIANA

ILEX GEORGEI

ILEX HOOKERI

ILEX MELANOTHRICHA

ILEX PERADO

ILEX PERADO PLATYPHYLLA

ILEX ROTUNDA

ILLICIUM ANISATUM

ILLICIUM FLORIDANUM

ILLICIUM HENRYI

INDIGOFERA DECORA

INDIGOFERA DECORA ALBA

INDIGOFERA HEBEPETALA

INDIGOFERA HETERANTHA

INDIGOFERA KIRILOWII

INDIGOFERA POTANINII

INDIGOFERA PSEUDOTINCTORIA

INDIGOFERA PULCHELLA

ITEA ILICIFOLIA

ITEA YUNNANENSIS

JASMINUM ANGULARE

JASMINUM AZORICUM

JASMINUM DISPERMUM

JASMINUM FLORIDUM

JASMINUM MESNYI

JASMINUM POLYANTHUM

JASMINUM SUAVISSIMUM

JASMINUM SUBHUMILE

JOVELLANA SINCLAIRII

JOVELLANA VIOLACEA

JUGLANS CALIFORNICA

JUNIPERUS ASHEI

JUNIPERUS CALIFORNICA

JUNIPERUS CEDRUS

JUNIPERUS FLACCIDA

JUNIPERUS FORMOSANA

JUNIPERUS MONOSPERMA

JUNIPERUS OSTEOSPERMA

JUNIPERUS PHOENICEA

JUNIPERUS PINCHOTII

JUNIPERUS PROCERA

KADSURA JAPONICA

KADSURA JAPONICA 'VARIEGATA'

KETELEERIA FORTUNEI

LAGERSTROEMIA INDICA

LAPAGERIA ROSEA

LARDIZABALA BITERNATA

LARIX GRIFFITHII

LAURELIA SERRATA

LAURUS NOBILIS

LAVANDULA LANATA

LAVANDULA STOECHAS

LAVATERA MARITIMA

LAVATERA OLBIA

LEONOTIS LEONORUS

LEPTOSPERMUM LAEVIGATUM

LEPTOSPERMUM LANIGERUM

LEPTOSPERMUM LIVERSIDGEI

LEPTOSPERMUM RODWAYANUM

LEPTOSPERMUM SCOPARIUM

LEPTOSPERMUM SCOPARIUM 'ALBO FLORE PLENO'

LEPTOSPERMUM SCOPARIUM 'BOSCAWENII'

LEPTOSPERMUM SCOPARIUM 'CHAPMANII'

LEPTOSPERMUM SCOPARIUM 'DECUMBENS'

LEPTOSPERMUM SCOPARIUM 'NANUM'

LEPTOSPERMUM SCOPARIUM 'NICHOLLSII'

LEPTOSPERMUM SCOPARIUM 'RED DAMASK'

LEPTOSPERMUM SCOPARIUM 'ROSEUM MULTIPETALUM'

LEPTOSPERMUM SCOPARIUM 'KEATLEYI'

LEPTOSPERMUM SERICEUM

LEYCESTERIA CROCOTHYRSOS

LIBOCEDRUS BIDWILLII

LIBOCEDRUS PLUMOSA

LIGUSTRUM CONFUSUM

LINDERA MEGAPHYLLA

LINDERA RUBRONERVIA

LIPPIA CITRIODORA

LITHOCARPUS DENSIFLORUS

LITHOCARPUS PACHYPHYLLUS

LITHOSPERMUM ROSMARINIFOLIUM

LOMATIA DENDATA

LOMATIA FERRUGINEA

LAURUS AZORICA

LONICERA HILDERBRANDIANA

LONICERA SPLENDIDA

LOROPETALUM CHINENSE

LUCULIA GRANDIFLORA

LUCULIA GRATISSIMA

LUCULIA PINCEANA

LUZURIAGA RADICANS

LYONOTHAMNUS FLORIBUNDUS ASPLENIFOLIUS

MAGNOLIA COCO

MAGNOLIA DELAVAYI

MAGNOLIA NITIDA

MAGNOLIA ROSTRATA

MAHONIA ACANTHIFOLIA

MAHONIA HAEMATOCARPA

MAHONIA LOMARIIFOLIA

MAHONIA NAPAULENSIS

MALLOTUS JAPONICUS

MANDEVILLA SUAVEOLENS

MANGLIETTIA INSIGNIS

MEDICAGO ARBOREA

MELALEUCA GIBBOSA

MELALEUCA HYPERICIFOLIA

MELALEUCA SQUAMEA

MELALEUCA SQUARROSA

MELALEUCA WILSONII

MELIANTHUS MAJOR

MELICOPE TERNATA

MELIOSMA PUNGENS

MELIOSMA TENUIS

MELIA AZEDARACH

MENZIESIA CILIICALYX

MENZIESIA CILIICALYX PURPUREA

MENZIESIA FURRUGINEA

MENZIESIA GLABELLA

MENZIESIA MULTIFLORA

MENZIESIA PILOSA

METROSIDEROS DIFFUSA

METROSIDEROS EXCELSA

METROSIDEROS HYPERICIFOLIA

METROSIDEROS KERMADECENSIS

METROSIDEROS LUCIDA

METROSIDEROS ROBUSTA

MICHELIA COMPRESSA

MICHELIA DOLTSOPA

MICHELIA FIGO

MICROSTROBUS FITZGERALDII

MICROSTROBUS NIPHOPHILUS

MIMULUS AURANTIACUS

MIMULUS PUNICEUS

MITRARIA COCCINEA

MUEHLENBECKIA COMPLEXA

MUTISIA CLEMATIS

MYOPORUM LAETUM

MYRSINE AUSTRALIS

MYRSINE NUMMULARIA

MYRTUS APICULATA

MYRTUS BIDEVILLEI

MYRTUS BULLATA

MYRTUS CHEQUEN

MYRTUS COMMUNIS

MYRTUS COMMUNIS 'FLORE PLENO'

MYRTUS COMMUNIS 'VARIEGATA'

MYRTUS COMMUNIS MICROPHYLLA

MYRTUS COMMUNIS TARENTINA

MYRTUS LECHLERANA

MYRTUS OBCORDATA

MYRTUS UGNI

MYRTUS UGNI 'VARIEGATA'

MYRTUS X RALPHII

NANDINA DOMESTICA

NEOLITSEA SERICEA

NERIUM OLEANDER

NOTELAEA EXCELSA

NOTHOFAGUS CUNNINGHAMII

NOTHOFAGUS MENZIESII

NOTHOFAGUS MOOREI

OCHNA SERRULATA

OLEARIA 'ZENNORENSIS'

OLEARIA ALBIDA

OLEARIA ARBORESCENS

OLEARIA CAPILLARIS

OLEARIA CHATAMICA

OLEARIA COLENSOI

OLEARIA ERUBESCENS

OLEARIA ERUBESCENS ILICIFOLIA

OLEARIA FLORIBUNDA

OLEARIA FROSTII

OLEARIA FURFURACEA

OLEARIA PACHYPHYLLA

OLEARIA PANICULATA

OLEARIA PHLOGOPAPPA

OLEARIA PHLOGOPAPPA SUBREPANDA

OLEARIA RAMULOSA

OLEARIA RANI

OLEARIA ROSSII

OLEARIA SEMIDENTATA

OLEARIA SOLANDRI

OLEARIA SPECIOSA

OLEARIA STELLULATA

OLEARIA STELLULATA 'SPLENDENS'

OLEARIA TOMENTOSA

OLEARIA TRAVERSII

OLEARIA VISCOSA

OLEARIA X EXCORTICATA

OLEARIA X SCILLONIENSIS

OLEA EUROPAEA

OSMANTHUS AMERICANUS

OSMANTHUS FRAGRANS

OSMANTHUS FRAGRANS AURANTIACUS

OSMANTHUS SUAVIS

OSTEOMELES SUBROTUNDA

OXYLOBUS ARBUTIFOLIUS

OXYPETALUM CAERULEUM

OZOTHAMNUS ERICIFOLIUS

OZOTHAMNUS ROSMARINIFOLIUS

OZOTHAMNUS THYRSOIDEUS

PACHYSTEGIA INSIGNIS

PACHYSTEGIA INSIGNIS MINOR

PANDOREA JASMINOIDES

PARAHEBE PERFOLIATA

PASSIFLORA 'ALLARDII'

PASSIFLORA 'EXONIENSIS'

PASSIFLORA ANTIOQUIENSIS

PASSIFLORA CAERULEA

PASSIFLORA CAERULEA 'CONSTANCE ELLIOTT'

PASSIFLORA EDULIS

PASSIFLORA RACEMOSA

PASSIFLORA X CAERULEA-RACEMOSA

PENSTEMON CORDIFOLIUS

PENSTEMON CORYMBOSUS

PENTAPTERYGIUM 'LUDGVAN CROSS'

PENTAPTERYGIUM SERPENS

PENTAPTERA SICULA

PERIPLOCA LAEVIGATA

PEUMUS BOLDUS

PENTAPTERYGIUM RUGOSUM

PHILADELPHUS MACULATUS

PHILESIA MAGELLANICA

PHLOMIS ITALICA

PHOTINIA BENTHAMIANA

PHOTINIA DAVIDSONIAE

PASSIFLORA UMBILICATA

PHOTINIA GLOMERATA

PHOTINIA INTEGRIFOLIA

PHOTINIA PRIONOPHYLLA

PHYGELIUS AEGUALIS

PHYLLOCLADUS ASPLENIFOLIUS

PHYLLOCLADUS GLAUCUS

PHYLLOCLADUS TRICHOMANOIDES

PHYTOLACCA DIOICA

PIMELEA DRUPACEA

PIMELEA FERRUGINEA

PIMELEA PROSTRATA

PINUS CANARIENSIS

PINUS CARABAEA

PINUS CHIHUAHANA

PINUS ELLIOTII

PINUS GREGGII

PINUS KESIYA

PINUS LEIOPHYLLA

PINUS LUCHUENSIS

PINUS MASSONIANA

PINUS MICHOACANA

PINUS MONTEZUMAE

PINUS MONTEZUMAE HARTWEGII

PINUS MONTEZUMAE LINDLEYI

PINUS MONTEZUMAE RUDIS

PINUS OOCARPA

PINUS PALUSTRIS

PINUS PATULA

PINUS PSEUDOSTROBUS

PINUS ROXBURGHII

PINUS TAEDA

PINUS TORREYANA

PIPTANTHUS LABURNIFOLIUS

PISTACIA TEREBINTHUS

PISTACIA VERA

PITTOSPORUM BICOLOR

PITTOSPORUM COLENSOI

PITTOSPORUM CORNIFOLIUM

PITTOSPORUM CRASSIFOLIUM

PITTOSPORUM DALLII

PITTOSPORUM DAPHNIPHYLLIOIDES

PITTOSPORUM EUGENIOIDES

PITTOSPORUM EUGENIOIDES 'VARIEGATUM'

PITTOSPORUM TENUIFOLIUM

PITTOSPORUM TENUIFOLIUM 'GARNETTII'

PITTOSPORUM TENUIFOLIUM 'JAMES STIRLING'

PITTOSPORUM TENUIFOLIUM 'PURPUREUM'

PITTOSPORUM TENUIFOLIUM 'SILVER QUEEN'

PITTOSPORUM TENUIFOLIUM 'VARIEGATUM'

PITTOSPORUM TENUIFOLIUM 'WARNHAM GOLD'

PITTOSPORUM TOBIRA

PITTOSPORUM TOBIRA 'VARIEGATUM'

PITTOSPORUM UNDULATUM

PITTOSPORUM UNDULATUM 'VARIEGATUM'

PLATANUS RACEMOSA

PODOCARPUS ACUTIFOLIUS

PODOCARPUS DACRYDIOIDES

PODOCARPUS ELATUS

PODOCARPUS FALCATUS

PODOCARPUS FERRUGINEUS

PODOCARPUS GRACILIOR

PODOCARPUS HALLII

PODOCARPUS HALLII 'AUREUS'

PODOCARPUS MACROPHYLLUS

PODOCARPUS MACROPHYLLUS 'ANGUSTIFOLIUS'

PODOCARPUS MACROPHYLLUS 'ARGENTEUS'

PODOCARPUS NAGI

PODOCARPUS SALIGNUS

PODOCARPUS SPICATUS

PODOCARPUS TOTARA

POLYGALA 'DALMAISIANA'

POLYGALA VIRGATA

POMADERRIS APETALA

POMADERRIS PHYLICIFOLIA

PROSTRANTHERA ASPALATHOIDES

PROSTRANTHERA LASIANTHOS

PROSTRANTHERA MELISSIFOLIA PARVIFOLIA

PROSTRANTHERA OVALIFOLIA

PROSTRANTHERA ROTUNDIFOLIA

PRUNUS CAMPANULATA

PRUNUS CAMPANULATA 'PLENA'

PRUNUS CERASOIDES RUBEA

PRUNUS ILICIFOLIA

PRUNUS LYONII

PRUNUS SCOPARIA

PSEUDOPANAX CRASSIFOLIUS

PSEUDOPANAX DAVIDII

PSEUDOPANAX FEROX

PSEUDOPANAX LAETUS

PSEUDOPANAX LESSONII

PSEUDOWINTERA COLORATA

PSORALEA PINNATA

PUERARIA LOBATA

PUNICA GRANATUM

PUNICA GRANATUM 'FLORE PLENO'

PUNICA GRANATUM 'NANA'

QUERCUS ALNIFOLIA

QUERCUS ARIZONICA

QUERCUS HYPOLEUCA

QUERCUS INCANA

QUERCUS RETICULATA

RAPHIOLEPIS INDICA

RAPHIOLEPIS UMBELLATA

RAPHIOLEPIS X DELACOURII

RAPHIOLEPIS X DELACOURII 'COATES CRIMSON'

REEVSIA PUBESCENS

REEVSIA THYRSOIDEA

RHAMNUS ALATERNA

RHAMNUS ALATERNA 'ANGUSTIFOLIA'

RHAMNUS ALATERNA 'ARGENTEOVARIEGATA'

RHAPHITHAMNUS SPINOSUS

RHODOCHITON ATROSANGUINEUM

RHODODENDRON ABERCONWAYI

RHODODENDRON ADENOGYNUM

RHODODENDRON ANNAE

RHODODENDRON AURITUM

RHODODENDRON BULLATUM

RHODODENDRON CRASSUM

RHODODENDRON DELAVAYI

RHODODENDRON DIAPREPES

RHODODENDRON ELLIOTTII

RHODODENDRON ERIOGYNUM

RHODODENDRON ERITIMUM

RHODODENDRON ERYTHROCALYX

RHODODENDRON GRANDE

RHODODENDRON GRIFFITHIANUM

RHODODENDRON HABROTRICHUM

RHODODENDRON HOOKERI

RHODODENDRON INDICUM

RHODODENDRON IRRORATUM

RHODODENDRON JOHNSTONEANUM

RHODODENDRON LOPSANGIANUM

RHODODENDRON MACROSEPALUM

RHODODENDRON MACULIFERUM

RHODODENDRON MAGNIFICUM

RHODODENDRON MARIESII

RHODODENDRON MEDDIANUM

RHODODENDRON MEGERATUM

RHODODENDRON OBLONGIFOLIUM

RHODODENDRON OLDHAMII

RHODODENDRON OLEIFOLIUM

RHODODENDRON OVATUM

RHODODENDRON PULCHRUM

RHODODENDRON PURALBUM

RHODODENDRON SCABRIFOLIUM

RHODODENDRON SCABRUM

RHODODENDRON SHEPHERDII

RHODODENDRON SMITHII

RHODODENDRON SPICIFERUM

RHODODENDRON SPINULIFERUM

RHODODENDRON TASHIROI

RHODODENDRON THOMSONII

RHODODENDRON VENATOR

RHODODENDRON VIRGATUM

RHODODENDRON WILLIAMSIANUM

RHODODENDRON ZEYLANICUM

RHODOLEIA CHAMPIONII

RHUS SUCCEDANEA

RIBES VIBURNIFOLIUM

RICHEA DRACHOPHYLLA

ROSMARINUS LAVANDULACEUS

ROSMARINUS OFFICINALIS 'BENENDEN BLUE'

ROSMARINUS OFFICINALIS 'TUSCAN BLUE'

ROSA BRACTEATA

RUBUS LINEATUS

RUBUS PARVUS

RUBUS SQUARROSUS

SALVIA AUREA

SALVIA FULGENS

SALVIA GESNERIFLORA

SALVIA GREGGII

SALVIA GUARANTICA

SALVIA INTERRUPTA

SALVIA INVOLUCRATA

SALVIA INVOLUCRATA 'BETHELLII'

SALVIA MEXICANA MINOR

SALVIA MICROPHYLLA

SALVIA MICROPHYLLA NEUREPIA

SALVIA RUTILANS

SAPINDUS MUKOROSSI

SAPIUM SEBIFERUM

SARCOCOCCA SALIGNA

SCHIMA ARGENTEA

SCHIMA KHASIANA

SCHIMA NORONHAE

SCHIMA WALLICHII

SCHINUS MOLLE

SENECIO COMPACTUS

SENECIO HECTORIS

SENECIO HERITIERI

SENECIO HUNTII

SENECIO KIRKII

SENECIO LEUCOSTACHYS

SENECIO PERDICIOIDES

SMILAX ASPERA

SOLANUM JASMINOIDES

SOLANUM JASMINOIDES 'ALBUM'

SOLANUM LACINIATUM

SOLANUM VALDIVIENSE

SOLLYA HETEROPHYLLA

SOLLYA PARVIFLORA

SOPHORA PROSTRATA

SOPHORA TETRAPTERA

SOPHORA TETRAPTERA 'GRANDIFLORA'

SORBUS HARROWIANA

SPARMANNIA AFRICANA

SPHACELE CHAMAEDRYOIDES

SPHAERALCEA FENDLERI

STACHYURUS HIMALAICUS

STACHYURUS LANCIFOLIUS

STEWARTIA PTEROPETIOLATA

STRANVAESIA NUSSIA

STYRAX DASYANTHA

SUTHERLANDIA FRUTESCENS

TAIWANIA CRYPTOMERIOIDES

TAIWANIA FLOUSIANA

TAXODIUM MUCRONATUM

TECOMARIA CAPENSIS

TERNSTROEMIA GYMNANTHERA

TERNSTROEMIA GYMNANTHERA 'VARIEGATA'

TETRACLINIS ARTICULATA

TEUCRIUM FRUTICANS

TEUCRIUM FRUTICANS 'AZUREUM'

TIBOUCHINA URVILLIANA

TRACHELOSPERMUM ASIATICUM

TRACHELOSPERMUM JASMINOIDES

TRIPTERYGIUM WILFORDII

TSUGA DUMOSA

TSUGA FORMOSANA

TSUGA YUNNANENSIS

VACCINIUM GAULTHERIIFOLIUM

VACCINIUM NUMMULARIA

VACCINIUM URCEOLATUM

VERBENA TRIDENS

VESTIA FOETIDA

VIBURNUM CYLINDRICUM

VIBURNUM ERUBESCENS

VIBURNUM ODORATISSIMUM

VIBURNUM RIGIDUM

VIBURNUM SUSPENSUM

VIBURNUM TINUS 'VARIEGATUM'

VIBURNUM TINUS HIRTULUM

VILLARESIA MUCRONATA

WATTAKAKA SINENSIS

WEIGELA HORTENSIS

WEIGELA HORTENSIS 'NIVEA'

WEINMANNIA RACEMOSA

WEINMANNIA TRICHOSPERMA

WESTRINGIA ROSMARINIFORMIS

WIDDRINGTONIA CUPRESSOIDES

WIDDRINGTONIA JUNIPEROIDES

WIDDRINGTONIA SCHWARZII

WIDDRINGTONIA WHYTEI

XYLOSMA JAPONICUM

X FATSHEDERA LIZEI

X FATSHEDERA LIZEI 'VARIEGATA'

X HALMIOCISTUS WINTONENSIS

X MACLUDRANIA HYBRIDA

X PHILAGERIA VEITCHII

YUCCA ARIZONICA

YUCCA BREVIFOLIA

YUCCA PARVIFLORA ENGELMANNII

YUCCA WHIPPEI

ZAUSCHNERIA CALIFORNICA

ZAUSCHNERIA CALIFORNICA LATIFOLIA

ZAUSCHNERIA CANA

APPENDIX D

TAXA INTOLERANCE DATA

PLANT INTOLERANCE RATINGS

Key to abbreviations :

T. = Intolerance rating of specific soil textures.
D. = Intolerance rating of soil depth.
M. = Intolerance rating of soil moisture.
P. = Intolerance rating of soil pH.
C. = Intolerance rating of maritime conditions.
E. = Intolerance rating of exposure.
L. = Intolerance rating of late spring frosts.
S. = Intolerance rating of seasonal waterlogging.

Plant Name.	T	D	M	P	C	E	L	S
ABELIA X GRANDIFLORA	1	1	4	1	3	5	2	3
ABIES BALSAMEA 'HUDSONIA'	1	3	3	4	3	5	2	3
ABIES CONCOLOR	1	3	3	1	3	5	2	3
ABIES GRANDIS	1	3	3	1	3	4	2	3
ABIES PINSAPO	1	1	3	1	3	4	2	3
ACER CAMPESTRE	1	1	1	4	3	5	3	3
ACER CAPPADOCICUM 'RUBRUM'	1	1	1	2	3	3	2	3
ACER DAVIDII 'GEORGE FORREST'	1	1	1	1	3	1	2	3
ACER GRISEUM	1	1	4	1	3	3	2	3
ACER HELDREICHII	1	1	4	1	3	3	2	3
ACER JAPONICUM 'ACONITIFOLIUM'	1	1	3	1	3	3	3	3
ACER JAPONICUM 'AUREUM'	1	1	3	1	3	3	3	3
ACER NEGUNDO	1	1	4	1	3	5	2	3
ACER NEGUNDO 'VARIEGATUM'	1	1	4	1	3	5	2	3
ACER PALMATUM	1	1	4	1	3	3	2	3
ACER PALMATUM 'ATROPURPUREUM'	1	1	4	1	3	3	2	3
ACER PALMATUM 'DISSECTUM'	1	1	4	1	3	3	2	3
ACER PALMATUM 'DISSECTUM ATROPURPUREUM'	1	1	4	1	3	3	2	3
ACER PALMATUM 'HEPTALOBUM OSAKAZUKI'	1	1	4	1	3	3	2	3

Plant Name.	T	D	M	P	C	E	L	S
ACER PALMATUM 'SENKAKI'	1	1	4	1	3	3	2	3
ACER PLATANOIDES	1	1	4	1	3	5	2	3
ACER PLATANOIDES 'COLUMNARE'	1	1	1	1	3	5	2	3
ACER PLATANOIDES 'CRIMSON KING'	1	1	4	1	3	5	2	3
ACER PLATANOIDES 'DRUMMONDII'	1	1	4	1	3	4	2	3
ACER PLATANOIDES 'SCHWEDLERI'	1	1	4	1	3	5	2	3
ACER PSEUDOPLATANUS	1	1	1	1	2	5	2	3
ACER PSEUDOPLATANUS 'ATROPURPUREUM'	1	1	4	1	2	4	2	3
ACER PSEUDOPLATANUS 'BRILLIANTISSIMUM'	1	1	1	1	2	5	2	3
ACER PSEUDOPLATANUS 'ERECTUM'	1	1	1	1	2	5	2	3
ACER PSEUDOPLATANUS 'LEOPOLDII'	1	1	4	1	2	5	2	3
ACER PSEUDOPLATANUS 'WORLEEI'	1	1	4	1	2	5	2	3
ACER RUBRUM	1	1	1	4	3	5	2	3
ACER SACCHARINUM	1	1	4	1	3	3	2	3
ACER SACCHARINUM 'PYRAMIDALE'	1	1	4	1	3	3	2	3
ACER X LOBELII	1	1	4	1	3	3	2	3
ACTINIDIA CHINENSIS	1	1	4	1	3	3	2	3
ACTINIDIA KOLOMIKTA	1	1	4	1	3	3	2	3
AESCULUS HIPPOCASTANUM	1	1	4	1	3	5	2	3
AESCULUS HIPPOCASTANUM 'BAUMANNII'	1	1	4	1	3	5	2	3
AESCULUS INDICA	1	1	4	1	3	4	3	3
AESCULUS PARVIFLORA	1	1	4	1	3	4	2	3
AESCULUS X CARNEA 'BRIOTII'	1	1	4	1	3	5	2	3
AILANTHUS ALTISSIMA	1	1	4	1	3	4	2	3
AKEBIA QUINATA	1	1	4	1	3	4	2	3

Plant Name.	T	D	M	P	C	E	L	S
ALNUS CORDATA	1	1	3	1	3	5	2	2
ALNUS FIRMA HIRTELLA	1	1	3	1	3	5	2	2
ALNUS GLUTINOSA	1	1	3	1	3	5	2	2
ALNUS INCANA	1	1	3	1	3	5	2	2
AMELANCHIER LAMARCKII	1	1	4	4	3	5	2	3
ARALIA ELATA	1	1	4	1	3	3	3	3
ARBUTUS UNEDO	1	1	4	1	3	4	2	3
ARISTOLOCHIA MACROPHYLLA	1	1	4	1	3	3	2	3
ARONIA ARBUTIFOLIA	1	3	4	4	3	4	2	3
ARTEMISIA ABROTANUM	3	1	4	1	3	3	2	3
ARTEMISIA ARBORESCENS	3	3	4	1	3	2	2	3
ATRIPLEX HALIMUS	1	1	4	1	2	5	2	3
AUCUBA JAPONICA	1	1	4	1	3	5	2	3
AUCUBA JAPONICA 'CROTONIFOLIA'	1	1	4	1	3	5	2	3
AUCUBA JAPONICA 'NANA ROTUNDIFOLIA'	1	1	4	1	3	5	2	3
AUCUBA JAPONICA 'VARIEGATA'	1	1	4	1	3	5	2	3
AZALEA 'ADDY WERY'	1	1	4	4	3	4	2	3
AZALEA 'ATALANTA'	1	1	4	4	3	4	2	3
AZALEA 'AZUMA-KAGAMI'	1	1	4	4	3	4	2	3
AZALEA 'BENIGIRI'	1	1	4	4	3	4	2	3
AZALEA 'BERRYROSE'	1	1	4	4	3	4	2	3
AZALEA 'BETTY'	1	1	4	4	3	4	2	3
AZALEA 'BLUE DANUBE'	1	1	4	4	3	4	2	3
AZALEA 'CECILE'	1	1	4	4	3	4	2	3
AZALEA 'CORNEILLE'	1	1	4	4	3	4	2	3
AZALEA 'DAVIESII'	1	1	4	4	3	4	2	3
AZALEA 'EDDY'	1	1	4	4	3	4	2	3

Plant Name.	T	D	M	P	C	E	L	S
AZALEA 'EMBLEY CRIMSON'	1	1	4	4	3	4	2	3
AZALEA 'FEDORA'	1	1	4	4	3	4	2	3
AZALEA 'GIBRALTAR'	1	1	4	4	3	4	2	3
AZALEA 'HINODEGIRI'	1	1	4	4	3	4	2	3
AZALEA 'HINOMAYO'	1	1	4	4	3	4	2	3
AZALEA 'HOMEBUSH'	1	1	4	4	3	4	2	3
AZALEA 'JOHN CAIRNS'	1	1	4	4	3	4	2	3
AZALEA 'KIRIN'	1	1	4	4	3	4	2	3
AZALEA 'KLONDYKE'	1	1	4	4	3	4	2	3
AZALEA 'KNAP HILL RED'	1	1	4	4	3	4	2	3
AZALEA 'KURE-NO-YUKI'	1	1	4	4	3	4	2	3
AZALEA 'MOTHER'S DAY'	1	1	4	4	3	4	2	3
AZALEA 'NARCISSIFLORUM'	1	1	4	4	3	4	2	3
AZALEA 'PALESTRINA'	1	1	4	4	3	4	2	3
AZALEA 'PERSIL'	1	1	4	4	3	4	2	3
AZALEA 'SHIN-SEIKAI'	1	1	4	4	3	4	2	3
AZALEA 'SILVER SLIPPER'	1	1	4	4	3	4	2	3
AZALEA 'VUYK'S ROSYRED'	1	1	4	4	3	4	2	3
AZALEA 'VUYK'S SCARLET'	1	1	4	4	3	4	2	3
AZARA MICROPHYLLA	1	1	4	1	3	2	3	3
BERBERIS 'BARBAROSSA'	1	1	4	1	3	4	2	3
BERBERIS BUXIFOLIA 'NANA'	1	1	1	1	3	4	2	3
BERBERIS CANDIDULA	1	1	1	1	3	4	2	3
BERBERIS DARWINII	1	1	4	1	3	5	2	3
BERBERIS GAGNEPAINII	1	1	4	1	3	4	2	3
BERBERIS JULIANAE	1	1	1	1	3	4	2	3
BERBERIS PANLANENSIS	1	1	1	1	3	4	2	3
BERBERIS THUNBERGII	1	1	4	1	3	4	2	3

Plant Name.	T	D	M	P	C	E	L	S
BERBERIS THUNBERGII 'ATROPURPUREA NANA'	1	1	4	1	3	4	2	3
BERBERIS THUNBERGII 'ROSE GLOW'	1	1	4	1	3	4	2	3
BERBERIS THUNBERGII ATROPURPUREA	1	1	4	1	3	4	2	3
BERBERIS VERRUCULOSA	1	1	4	1	3	4	2	3
BERBERIS WILSONIAE	1	1	4	1	3	4	2	3
BERBERIS X LOLOGENSIS	1	1	1	1	3	4	2	3
BERBERIS X OTTAWENSIS 'PURPUREA'	1	1	1	1	3	4	2	3
BERBERIS X STENOPHYLLA	1	1	4	1	3	4	2	3
BERBERIS X STENOPHYLLA 'IRWINII'	1	1	4	1	3	4	2	3
BETULA COSTATA	1	1	1	1	3	5	2	3
BETULA JACQUEMONTII	1	1	1	1	3	5	2	3
BETULA NIGRA	1	1	1	1	3	5	2	2
BETULA PAPYRIFERA	1	1	1	1	3	5	2	3
BETULA PENDULA	1	1	1	1	3	5	2	3
BETULA PENDULA 'DALECARLICA'	1	1	1	1	3	5	2	3
BETULA PENDULA 'TRISTIS'	1	1	1	1	3	5	2	3
BETULA PENDULA 'YOUNGII'	1	1	1	1	3	5	2	3
BETULA PUBESCENS	1	1	1	1	3	5	2	2
BUDDLEIA 'LOCHINCH'	1	1	1	4	3	4	2	3
BUDDLEIA ALTERNIFOLIA	1	1	4	1	3	4	2	3
BUDDLEIA DAVIDII 'BLACK NIGHT'	1	1	1	1	2	5	2	3
BUDDLEIA DAVIDII 'EMPIRE BLUE'	1	1	1	1	2	5	2	3
BUDDLEIA DAVIDII 'FASCINATING'	1	1	1	1	2	5	2	3
BUDDLEIA DAVIDII 'ROYAL RED'	1	1	1	1	2	5	2	3

Plant Name.	T	D	M	P	C	E	L	S
BUDDLEIA DAVIDII 'WHITE BOUQUET'	1	1	1	1	2	5	2	3
BUDDLEIA GLOBOSA	1	1	1	4	3	4	2	3
BUXUS SEMPERVIRENS	1	1	1	1	3	5	2	3
BUXUS SEMPERVIRENS 'HANDSWORTHENSIS'	1	1	1	1	3	5	2	3
CALLICARPA BODINIERI	1	3	4	1	2	4	2	3
CALLUNA VULGARIS	1	1	1	4	3	5	2	3
CALLUNA VULGARIS 'ALBA PLENA'	1	1	1	4	3	5	2	3
CALLUNA VULGARIS 'ALPORTII'	1	1	1	4	3	5	2	3
CALLUNA VULGARIS 'BLAZEAWAY'	1	1	1	4	3	5	2	3
CALLUNA VULGARIS 'COUNTY WICKLOW'	1	1	1	4	3	5	2	3
CALLUNA VULGARIS 'H.E. BEALE'	1	1	1	4	3	5	2	3
CALLUNA VULGARIS 'MAIRS'S VARIETY'	1	1	1	4	3	5	2	3
CALLUNA VULGARIS 'PETER SPARKES'	1	1	1	4	3	5	2	3
CALLUNA VULGARIS 'ROBERT CHAPMAN'	1	1	1	4	3	5	2	3
CALLUNA VULGARIS 'ROSALIND'	1	1	1	4	3	5	2	3
CALLUNA VULGARIS 'SERLEI'	1	1	1	4	3	5	2	3
CALLUNA VULGARIS 'SILVER QUEEN'	1	1	1	4	3	5	2	3
CALLUNA VULGARIS 'SISTER ANNE'	1	1	1	4	3	5	2	3
CALOCEDRUS DECURRENS	1	1	4	1	3	4	2	3
CAMELLIA 'LEONARD MESSEL'	1	1	4	4	3	3	3	3
CAMELLIA JAPONICA	1	1	4	4	3	3	3	3
CAMELLIA JAPONICA 'ALBA PLENA'	1	1	4	4	3	3	3	3
CAMELLIA JAPONICA 'ALBA SIMPLEX'	1	1	4	4	3	3	3	3

Plant Name.	T	D	M	P	C	E	L	S
CAMELLIA JAPONICA 'CONTESSA LAVINIA MAGGI'	1	1	4	4	3	3	3	3
CAMELLIA JAPONICA 'DONCKELARII'	1	1	4	4	3	3	3	3
CAMELLIA JAPONICA 'ELEGANS'	1	1	4	4	3	3	3	3
CAMELLIA JAPONICA 'GLOIRE DE NANTES'	1	1	4	4	3	3	3	3
CAMELLIA JAPONICA 'JUPITER'	1	1	4	4	3	3	3	3
CAMELLIA JAPONICA 'LADY CLARE'	1	1	4	4	3	3	3	3
CAMELLIA JAPONICA 'MATHOTIANA'	1	1	4	4	3	3	3	3
CAMELLIA JAPONICA 'NAGASAKI'	1	1	4	4	3	3	3	3
CAMELLIA JAPONICA 'TRICOLOR'	1	1	4	4	3	3	3	3
CAMELLIA X WILLIAMSII 'DONATION'	1	1	4	4	3	3	3	3
CAMELLIA X WILLIAMSII 'J.C. WILLIAMS'	1	1	4	4	3	3	3	3
CAMPSIS X TAGLIABUANA 'MADAME GALEN'	3	1	4	1	3	4	2	3
CARAGANA ARBORESCENS	1	1	1	1	2	5	2	3
CARPINUS BETULUS	1	3	4	1	3	5	2	3
CARPINUS BETULUS 'FASTIGIATA'	1	3	4	1	3	5	2	3
CARYOPTERIS X CLANDONENSIS 'HEAVENLY BLUE'	3	1	4	3	3	4	2	3
CASTANEA SATIVA	1	1	4	1	2	5	2	3
CATALPA BIGNONIOIDES	1	1	4	1	3	4	2	3
CATALPA BIGNONIOIDES 'AUREA'	1	1	4	1	3	4	2	3
CEANOTHUS 'AUTUMNAL BLUE'	1	3	4	4	2	2	2	3
CEANOTHUS 'BURKWOODII'	1	3	4	4	2	2	2	3
CEANOTHUS 'CASCADE'	1	3	4	4	2	2	2	3
CEANOTHUS 'GLOIRE DE VERSAILLES'	1	3	4	4	2	2	2	3

Plant Name.	T	D	M	P	C	E	L	S
CEANOTHUS 'TOPAZ'	1	3	4	4	2	2	2	3
CEANOTHUS DENTATUS	1	3	4	4	2	2	2	3
CEANOTHUS IMPRESSUS	1	3	4	4	2	2	2	3
CEANOTHUS THYRSIFLORUS REPENS	1	3	4	4	2	2	2	3
CEANOTHUS X VEITCHIANUS	1	3	4	4	2	2	2	3
CEDRUS ATLANTICA	1	1	4	1	3	5	2	3
CEDRUS ATLANTICA GLAUCA	1	1	4	1	3	5	2	3
CEDRUS DEODARA	1	1	4	1	3	5	2	3
CELASTRUS ORBICULATUS	1	1	1	1	3	4	2	3
CERATOSTIGMA WILLMOTTIANUM	3	1	4	1	3	3	2	3
CERCIDIPHYLLUM JAPONICUM	3	3	4	1	3	4	3	3
CERCIS SILIQUASTRUM	1	3	4	1	3	4	2	3
CHAENOMELES JAPONICA	1	3	4	1	3	5	2	3
CHAENOMELES SPECIOSA 'MOERLOOSI'	1	3	4	1	3	5	2	3
CHAENOMELES SPECIOSA 'NIVALIS'	1	3	4	1	3	5	2	3
CHAENOMELES X SUPERBA 'CRIMSON & GOLD'	1	3	4	1	3	5	2	3
CHAENOMELES X SUPERBA 'FIRE DANCE'	1	3	4	1	3	5	2	3
CHAENOMELES X SUPERBA 'NICOLINE'	1	3	4	1	3	5	2	3
CHAENOMELES X SUPERBA 'PINK LADY'	1	3	4	1	3	5	2	3
CHAENOMELES X SUPERBA 'ROWALLANE'	1	3	4	1	3	5	2	3
CHAMAECYPARIS LAWSONIANA	1	1	3	1	3	5	2	3
CHAMAECYPARIS LAWSONIANA 'ALLUMII'	1	1	3	1	3	5	2	3
CHAMAECYPARIS LAWSONIANA 'COLUMNARIS'	1	1	3	1	3	5	2	3

Plant Name.	T	D	M	P	C	E	L	S
CHAMAECYPARIS LAWSONIANA 'ELLWOODII'	1	1	3	1	3	5	2	3
CHAMAECYPARIS LAWSONIANA 'FLETCHERI'	1	1	3	1	3	5	2	3
CHAMAECYPARIS LAWSONIANA 'GIMBORNII'	1	1	3	1	3	5	2	3
CHAMAECYPARIS LAWSONIANA 'GREEN HEDGER'	1	1	3	1	3	5	2	3
CHAMAECYPARIS LAWSONIANA 'KILMACURRAGH'	1	1	3	1	3	5	2	3
CHAMAECYPARIS LAWSONIANA 'LANEI'	1	1	3	1	3	5	2	3
CHAMAECYPARIS LAWSONIANA 'MINIMA AUREA'	1	1	3	1	3	5	2	3
CHAMAECYPARIS LAWSONIANA 'PEMBURY BLUE'	1	1	3	1	3	5	2	3
CHAMAECYPARIS LAWSONIANA 'POTTENII'	1	1	3	1	3	5	2	3
CHAMAECYPARIS LAWSONIANA 'STARDUST'	1	1	3	1	3	5	2	3
CHAMAECYPARIS LAWSONIANA 'STEWARTII'	1	1	3	1	3	5	2	3
CHAMAECYPARIS OBTUSA 'NANA AUREA'	1	1	3	1	3	5	2	3
CHAMAECYPARIS OBTUSA 'NANA GRACILIS'	1	1	3	1	3	5	2	3
CHAMAECYPARIS PISIFERA 'BOULEVARD'	1	1	3	1	3	5	2	3
CHIMONANTHUS PRAECOX	1	3	4	1	3	4	2	3
CHOISYA TERNATA	3	3	4	1	2	3	2	3
CISTUS 'PEGGY SANNONS'	3	3	4	1	2	3	2	2
CISTUS 'SILVER PINK'	3	3	4	1	2	3	2	2
CISTUS LAURIFOLIUS	3	3	4	1	2	3	2	2
CISTUS POPULIFOLIUS	3	3	4	1	2	3	2	2
CISTUS X CORBARIENSIS	3	3	4	1	2	3	2	2

Plant Name.	T	D	M	P	C	E	L	S
CISTUS X CYPRIUS	3	3	4	1	2	3	2	2
CISTUS X LUSITANICUS 'DECUMBENS'	3	3	4	1	2	3	2	2
CISTUS X PULVERULENTUS	3	3	4	1	2	3	2	2
CISTUS X PURPUREUS	3	3	4	1	2	3	2	2
CLEMATIS 'BARBARA JACKMAN'	1	1	4	3	3	4	2	3
CLEMATIS 'BEES JUBILEE'	1	1	4	3	3	4	2	3
CLEMATIS 'COMTESSE DE BOUCHAUD'	1	1	4	3	3	4	2	3
CLEMATIS 'DUCHESS OF EDINBURGH'	1	1	4	3	3	4	2	3
CLEMATIS 'ERNEST MARKHAM'	1	1	4	3	3	4	2	3
CLEMATIS 'H.F. YOUNG'	1	1	4	3	3	4	2	3
CLEMATIS 'HAGLEY HYBRID'	1	1	4	3	3	4	2	3
CLEMATIS 'HENRYI'	1	1	4	3	3	4	2	3
CLEMATIS 'JACKMANII SUPERBA'	1	1	4	3	3	4	2	3
CLEMATIS 'LAZURSTERN'	1	1	4	3	3	4	2	3
CLEMATIS 'MADAME E. ANDRE'	1	1	4	3	3	4	2	3
CLEMATIS 'MARIE BOISSELOT'	1	1	4	3	3	4	2	3
CLEMATIS 'MRS. CHOLMONDELY'	1	1	4	3	3	4	2	3
CLEMATIS 'NELLY MOSER'	1	1	4	3	3	4	2	3
CLEMATIS 'PERLE D' AZUR'	1	1	4	3	3	4	2	3
CLEMATIS 'THE PRESIDENT'	1	1	4	3	3	4	2	3
CLEMATIS 'VILLE DE LYON'	1	1	4	3	3	4	2	3
CLEMATIS 'VYVYAN PENNELL'	1	1	4	3	3	4	2	3
CLEMATIS 'W.E. GLADSTONE'	1	1	4	3	3	4	2	3
CLEMATIS 'WILLIAM KENNETT'	1	1	4	3	3	4	2	3
CLEMATIS ARMANDII	1	1	4	1	3	2	2	3
CLEMATIS MACROPETALA	1	1	4	1	3	4	2	3

Plant Name.	T	D	M	P	C	E	L	S
CLEMATIS MACROPETALA 'MARKHAM'S PINK'	1	1	4	1	3	4	2	3
CLEMATIS MONTANA RUBENS	1	1	4	1	3	4	2	3
CLEMATIS MONTANA 'TETRAROSE'	1	1	4	1	3	4	2	3
CLEMATIS MONTANA GRANDIFLORA	1	1	4	1	3	4	2	3
CLEMATIS ORIENTALIS	1	1	4	1	3	4	2	3
CLEMATIS TANGUTICA	1	1	4	1	3	4	2	3
CLEMATIS VITALBA	1	1	4	1	3	5	2	3
CLERODENDRUM TRICHOTOMUM FARGESII	1	3	3	1	3	4	3	3
CLETHRA ALNIFOLIA 'PANICULATA'	1	3	4	4	3	4	2	3
COLUTEA ARBORESCENS	1	1	4	3	2	5	2	3
CORDYLINE AUSTRALIS	3	3	4	1	2	2	3	3
CORNUS ALBA 'ELEGANTISSIMA'	1	3	1	1	3	4	2	3
CORNUS ALBA 'SIBERICA'	1	3	1	1	3	4	2	3
CORNUS ALBA 'SPAETHII'	1	3	1	1	3	4	2	3
CORNUS FLORIDA RUBRA	1	3	1	1	3	4	2	3
CORNUS KOUSA CHINENSIS	1	3	1	1	3	4	2	3
CORNUS MAS	1	3	1	1	3	4	2	3
CORNUS SANGUINEA	1	3	1	1	3	4	2	3
CORNUS STOLONIFERA 'FLAVIRAMEA'	1	3	1	1	3	4	2	3
CORYLOPSIS PAUCIFLORA	3	1	4	4	3	4	2	3
CORYLOPSIS WILLMOTTIAE	3	1	4	1	3	4	2	3
CORYLUS AVELLANA	1	1	4	1	3	4	2	3
CORYLUS AVELLANA 'CONTORTA'	1	1	4	1	3	4	2	3
CORYLUS COLURNA	1	1	4	1	3	4	2	3
CORYLUS MAXIMA 'PURPUREA'	1	1	1	1	3	4	2	3
COTINUS COGGYGRIA	1	1	4	1	3	4	2	3

Plant Name.	T	D	M	P	C	E	L	S
COTINUS COGGYGRIA 'FLAME'	1	1	4	1	3	4	2	3
COTINUS COGGYGRIA 'ROYAL PURPLE'	1	1	4	1	3	4	2	3
COTONEASTER 'DONARD'S GEM'	1	1	4	1	2	4	2	3
COTONEASTER 'EXBURIENSIS'	1	1	4	1	2	4	2	3
COTONEASTER 'HYBRIDUS PENDULUS'	1	1	4	1	2	4	2	3
COTONEASTER 'JOHN WATERER'	1	1	4	1	2	4	2	3
COTONEASTER 'SKOGHOLM'	1	1	1	1	2	4	2	3
COTONEASTER CONSPICUUS	1	1	4	1	2	5	2	3
COTONEASTER CONSPICUUS 'DECORUS'	1	1	4	1	2	5	2	3
COTONEASTER DAMMERI	1	1	4	1	2	4	2	3
COTONEASTER DISTICHUS TONGOLENSIS	1	1	4	1	2	4	2	3
COTONEASTER FRANCHETII STERNIANUS	1	1	4	2	2	4	2	3
COTONEASTER HORIZONTALIS	1	1	4	1	2	4	2	3
COTONEASTER LACTEUS	1	1	4	1	2	4	2	3
COTONEASTER MICROPHYLLUS	1	1	4	1	2	4	2	3
COTONEASTER SALICIFOLIUS 'AUTUMN FIRE'	1	1	4	1	2	4	2	3
COTONEASTER SALICIFOLIUS 'FRUCTO LUTEO'	1	1	4	1	2	4	2	3
COTONEASTER SALICIFOLIUS 'PARKTEPPICH'	1	1	4	1	2	4	2	3
COTONEASTER SALICIFOLIUS 'REPENS'	1	1	4	1	2	4	2	3
COTONEASTER SALICIFOLIUS FLOCOSSUS	1	1	4	1	2	4	2	3
COTONEASTER SIMONSII	1	1	4	1	2	4	2	3
COTONEASTER X WATERERI	1	1	4	1	2	4	2	3
CRATAEGUS MONOGYNA	1	1	1	1	2	5	2	3

Plant Name.	T	D	M	P	C	E	L	S
CRATAEGUS OXYCANTHA	1	1	1	1	2	5	2	3
CRATAEGUS OXYCANTHA 'PAUL'S SCARLET'	1	1	1	1	2	5	2	3
CRATAEGUS OXYCANTHA 'ROSEA FLORE PLENO'	1	1	1	1	2	5	2	3
CRATAEGUS PRUNIFOLIA	1	1	1	1	2	5	2	3
CRATAEGUS X GRIGNONENSIS	1	1	1	1	2	5	2	3
CRATAEGUS X LAVALLEI	1	1	1	1	2	5	2	3
CRYPTOMERIA JAPONICA	1	1	4	1	3	5	2	3
CRYPTOMERIA JAPONICA 'ELEGANS'	1	1	4	1	3	5	2	3
CRYPTOMERIA JAPONICA 'ELEGANS NANA'	1	1	4	1	3	5	2	3
CRYPTOMERIA JAPONICA 'VILMORINIANA'	1	1	4	1	3	4	2	3
CUPRESSUS GLABRA 'PYRAMIDALIS'	1	1	4	1	3	5	2	3
CUPRESSUS MACROCARPA 'GOLD PILLAR'	1	1	4	1	2	4	2	3
CUPRESSUS MACROCARPA 'LUTEA'	1	1	4	1	2	4	2	3
CUPRESSUS SEMPERVIRENS	1	1	4	1	2	4	2	3
CYTISUS 'BURKWOODII'	1	3	4	1	2	4	2	3
CYTISUS 'GOLDFINCH'	1	3	4	1	2	4	2	3
CYTISUS 'KILLINEY RED'	1	3	4	1	2	4	2	3
CYTISUS 'MARIE BURKWOOD'	1	3	4	1	2	4	2	3
CYTISUS BATTANDIERI	1	3	4	1	2	4	2	3
CYTISUS MULTIFLORUS	3	3	4	4	3	4	2	3
CYTISUS SCOPARIUS	3	3	4	4	2	4	2	3
CYTISUS SCOPARIUS 'ANDREANUS'	3	3	4	4	2	4	2	3
CYTISUS SCOPARIUS 'CORNISH CREAM'	3	3	4	4	2	4	2	3
CYTISUS X BEANII	1	3	4	1	2	4	2	3

Plant Name.	T	D	M	P	C	E	L	S
CYTISUS X KEWENSIS	1	3	4	1	2	4	2	3
CYTISUS X PRAECOX	1	3	4	1	2	4	2	3
CYTISUS X PRAECOX 'ALLGOLD'	1	3	4	1	2	4	2	3
DAPHNE COLLINA NEAPOLITANA	3	3	4	4	3	4	2	3
DAPHNE LAUREOLA	3	3	4	4	3	4	2	3
DAPHNE MEZEREUM	3	3	4	1	3	4	2	3
DAPHNE ODORA 'AUREOMARGINATA'	3	3	4	4	3	4	2	3
DAPHNE X BURKWOODII	3	3	4	4	3	4	2	3
DAVIDIA INVOLUCRATA	1	3	3	1	3	4	2	3
DEUTZIA 'MONT ROSE'	1	3	3	1	3	4	3	3
DEUTZIA SCABRA 'PLENA'	1	3	3	1	3	4	3	3
DEUTZIA X ELEGANTISSIMA	1	3	3	1	3	4	3	3
DEUTZIA X MAGNIFICA	1	3	3	1	3	4	3	3
DEUTZIA X ROSEA 'CARMINEA'	1	3	3	1	3	4	3	3
ELAEAGNUS ANGUSTIFOLIA	1	3	4	4	2	5	2	3
ELAEAGNUS PUNGENS 'MACULATA'	1	3	4	4	2	5	2	3
ELAEAGNUS PUNGENS 'VARIEGATA'	1	3	4	4	2	5	2	3
ELAEAGNUS X EBBINGEI	1	3	4	4	2	5	2	3
EMBOTHRIUM COCCINEUM LANCEOLATUM	1	3	4	4	3	3	2	3
EMPETRUM NIGRUM	1	1	1	4	3	5	2	3
ENKIANTHUS CAMPANULATUS	1	3	4	4	3	4	2	3
ERICA ARBOREA 'ALPINA'	1	1	4	4	2	4	2	3
ERICA CARNEA 'AUREA'	1	3	4	1	3	5	2	3
ERICA CARNEA 'LOUGHRIGG'	1	1	4	1	3	5	2	3
ERICA CARNEA 'RUBY GLOW'	1	1	4	1	3	5	2	3
ERICA CARNEA 'SPRINGWOOD PINK'	1	1	4	1	3	5	2	3

Plant Name.	T	D	M	P	C	E	L	S
ERICA CARNEA 'SPRINGWOOD WHITE'	1	1	4	1	3	5	2	3
ERICA CARNEA 'VIVELLII'	1	1	4	1	3	5	2	3
ERICA CARNEA 'WINTER BEAUTY'	1	1	4	1	3	5	2	3
ERICA CINEREA	1	1	4	4	3	5	2	3
ERICA CINEREA 'ALBA MINOR'	1	1	4	4	3	5	2	3
ERICA CINEREA 'ATROSANGUINEA'	1	1	4	4	3	5	2	3
ERICA CINEREA 'C.D. EASON'	1	1	4	4	3	5	2	3
ERICA CINEREA 'GOLDEN HUE'	1	1	4	4	3	5	2	3
ERICA CINEREA 'P.S. PATRICK'	1	1	4	4	3	5	2	3
ERICA CINEREA 'VELVET NIGHT'	1	1	4	4	3	5	2	3
ERICA MEDITERRANEA 'BRIGHTNESS'	1	3	4	1	3	5	2	3
ERICA MEDITERRANEA 'SUPERBA'	1	3	4	1	3	5	2	3
ERICA MEDITERRANEA 'W.T. RACKLIFF'	1	3	4	1	3	5	2	3
ERICA TERMINALIS	1	1	4	1	3	5	2	3
ERICA TETRALIX	1	1	4	4	3	5	2	3
ERICA TETRALIX 'ALBA MOLLIS'	1	1	4	4	3	5	2	3
ERICA TETRALIX 'CON UNDERWOOD'	1	1	4	4	3	5	2	3
ERICA TETRALIX 'PINK GLOW'	1	1	4	4	3	5	2	3
ERICA VAGANS	1	1	4	4	3	5	2	3
ERICA VAGANS 'LYONESSE'	1	1	4	4	3	5	2	3
ERICA VAGANS 'MRS. D.F. MAXWELL'	1	1	4	4	3	5	2	3
ERICA VAGANS 'ST. KEVERNE'	1	1	4	4	3	5	2	3
ERICA X DARLEYENSIS 'ARTHUR JOHNSON'	1	3	4	1	3	5	2	3
ERICA X DARLEYENSIS 'DARLEY DALE'	1	3	4	1	3	5	2	3

Plant Name.	T	D	M	P	C	E	L	S
ERICA X DARLEYENSIS 'GEORGE RENDALL'	1	3	4	1	3	5	2	3
ERICA X DARLEYENSIS 'SILBERSCHMELZE'	1	3	4	1	3	5	2	3
ESCALLONIA 'APPLE BLOSSOM'	1	1	4	1	2	2	2	3
ESCALLONIA 'C.F. BALL'	1	1	4	1	2	2	2	3
ESCALLONIA 'CRIMSON SPIRE'	1	1	4	1	2	2	2	3
ESCALLONIA 'DONARD RADIANCE'	1	1	4	1	2	2	2	3
ESCALLONIA 'DONARD SEEDLING'	1	1	4	1	2	2	2	3
ESCALLONIA 'DONARD WHITE'	1	1	4	1	2	2	2	3
ESCALLONIA 'EDINENSIS'	1	1	4	1	2	2	2	3
ESCALLONIA 'INGRAMII'	1	1	4	1	2	2	2	3
ESCALLONIA 'IVEYI'	1	1	4	1	2	2	2	3
ESCALLONIA 'PRIDE OF DONARD'	1	1	4	1	2	2	2	3
ESCALLONIA MACRANTHA	1	1	4	1	2	2	2	3
EUCALYPTUS DALRYMPLEANA	1	3	1	1	2	4	2	3
EUCALYPTUS GUNNII	1	3	1	1	2	4	2	3
EUCALYPTUS NIPHOPHILA	1	3	1	1	2	4	2	3
EUCRYPHIA X NYMANSENSIS 'NYMANSAY'	3	3	4	1	3	2	2	3
EUONYMUS ALATUS 'COMPACTUS'	1	1	4	1	3	5	2	3
EUONYMUS EUROPAEUS	1	1	4	1	3	5	2	3
EUONYMUS EUROPAEUS 'RED CASCADE'	1	1	4	1	3	5	2	3
EUONYMUS FORTUNEI 'COLORATUS'	1	1	4	1	2	5	2	3
EUONYMUS FORTUNEI 'EMERALD AND GOLD'	1	1	4	1	2	5	2	3
EUONYMUS FORTUNEI 'SILVER QUEEN'	1	1	4	1	2	4	2	3
EUONYMUS FORTUNEI 'VARIEGATUS'	1	1	4	1	2	2	2	3

Plant Name.	T	D	M	P	C	E	L	S
EUONYMUS FORTUNEI RADICANS	1	1	4	1	2	5	2	3
EUONYMUS FORTUNEI VEGETUS	1	1	4	1	2	5	2	3
EUONYMUS JAPONICUS	1	1	4	1	2	5	2	3
EUONYMUS JAPONICUS 'OVATUS AUREUS'	1	1	4	1	2	5	2	3
EUONYMUS JAPONICUS ROBUSTUS	1	1	4	1	2	5	2	3
EUONYMUS SACHALINENSIS	1	1	4	1	3	4	2	3
EUONYMUS YEDOENSIS	1	1	4	1	3	4	2	3
EXOCHORDA MACRANTHA	1	1	4	4	3	4	2	3
FAGUS SYLVATICA	3	3	4	1	3	5	2	3
FAGUS SYLVATICA 'DAWYCK'	3	3	4	1	3	5	2	3
FAGUS SYLVATICA 'PENDULA'	3	3	4	1	3	5	2	3
FAGUS SYLVATICA 'PURPUREA PENDULA'	3	3	4	1	3	5	2	3
FAGUS SYLVATICA 'RIVERSII'	3	3	4	1	3	5	2	3
FAGUS SYLVATICA HETEROPHYLLA	3	3	4	1	3	5	2	3
FAGUS SYLVATICA PURPUREA	3	3	4	1	3	5	2	3
FATSIA JAPONICA	1	1	4	1	2	4	2	3
FICUS CARICA 'BROWN TURKEY'	3	3	4	1	3	3	2	3
FORSYTHIA LYNWOOD'	1	1	1	1	3	5	2	3
FORSYTHIA SUSPENSA	1	1	1	1	3	5	2	3
FORSYTHIA SUSPENSA ATROCAULIS	1	1	1	1	3	5	2	3
FOTHERGILLA MAJOR	3	1	4	4	3	4	2	3
FRANGULA ALNUS	1	1	1	1	3	5	2	3
FRAXINUS AMERICANA	1	3	4	1	2	5	2	3
FRAXINUS ANGUSTIFOLIA	1	3	4	1	2	5	2	3
FRAXINUS EXCELSIOR	1	3	4	1	2	5	3	3
FRAXINUS EXCELSIOR 'PENDULA'	1	3	4	1	2	5	3	3

Plant Name.	T	D	M	P	C	E	L	S
FRAXINUS EXCELSIOR 'WESTOFF GLORY'	1	3	4	1	2	5	3	3
FRAXINUS ORNUS	1	3	4	1	3	5	3	3
FRAXINUS OXYCARPA 'RAYWOOD'	1	3	4	1	2	5	3	3
FRAXINUS VELUTINA	1	3	4	1	3	4	3	3
FUCHSIA 'MADAME CORNELISSEN'	1	1	4	1	2	2	3	3
FUCHSIA 'MRS. POPPLE'	1	1	4	1	2	2	3	3
FUCHSIA 'RICCARTONII'	1	1	4	1	2	2	3	3
FUCHSIA MAGELLANICA 'VARIEGATA'	1	1	4	1	2	2	3	3
FUCHSIA MEGALLANICA GRACILIS	1	1	4	1	2	2	3	3
GARRYA ELIPTICA	1	3	1	1	2	4	2	3
GAULTHERIA PROCUMBENS	1	1	4	4	3	5	2	3
GAULTHERIA SHALLON	1	1	4	4	3	5	2	3
GENISTA AETNENSIS	1	1	4	1	2	5	2	3
GENISTA CINEREA	1	1	4	1	2	5	2	3
GENISTA HISPANICA	3	1	4	1	2	4	2	3
GENISTA LYDIA	1	1	4	1	2	5	2	3
GENISTA SAGITTALIS	3	1	4	1	2	5	2	3
GENISTA TINCTORIA 'ROYAL GOLD'	1	1	4	1	2	5	2	3
GINKGO BILOBA	1	1	4	1	3	5	2	3
GLEDITSIA TRIACANTHOS	3	1	4	1	3	5	2	3
GLEDITSIA TRIACANTHOS 'SUNBURST'	3	1	4	1	3	5	2	3
GRISELINIA LITTORALIS	1	1	4	1	2	3	3	3
HALIMIOCISTUS SAHUCII	3	1	4	1	3	2	3	3
HALIMIUM OCYMOIDES	3	1	4	1	2	2	3	3
HAMAMELIS MOLLIS	1	1	4	1	3	4	2	3
HAMAMELIS MOLLIS 'PALLIDA'	1	1	4	1	3	4	2	3

Plant Name.	T	D	M	P	C	E	L	S
HAMAMELIS X INTERMEDIA 'JELENA'	1	1	4	1	3	4	2	3
HEBE 'AUTUMN GLORY'	3	1	4	1	2	2	3	3
HEBE 'CARL TESCHNER'	3	1	4	1	2	2	3	3
HEBE 'GREAT ORME'	3	1	4	1	2	2	3	3
HEBE 'MARJORIE'	3	1	4	1	2	2	3	3
HEBE 'MIDSUMMER BEAUTY'	3	1	4	1	2	2	3	3
HEBE 'MRS. WINDER'	3	1	4	1	2	2	3	3
HEBE ALBICANS	3	1	4	1	2	2	3	3
HEBE CUPRESSOIDES	3	1	4	1	2	2	3	3
HEBE PIMELEOIDES 'GLAUCOCAERULEA'	3	1	4	1	2	2	3	3
HEBE PINGUIFOLIA 'PAGEI'	3	1	4	1	2	2	3	3
HEBE RAKAIENSIS	3	1	4	1	2	2	3	3
HEBE X FRANCISCANA 'BLUE GEM'	3	1	4	1	2	2	3	3
HEDERA CANARIENSIS 'VARIEGATA'	1	1	1	1	3	4	2	3
HEDERA COLCHICA	1	1	1	1	3	5	2	3
HEDERA COLCHICA 'DENTATA VARIEGATA'	1	1	1	1	3	5	2	3
HEDERA HELIX	1	1	1	1	3	5	2	3
HEDERA HELIX 'BUTTERCUP'	1	1	1	1	3	5	2	3
HEDERA HELIX 'GLACIER'	1	1	1	1	3	5	2	3
HEDERA HELIX 'GOLD HEART'	1	1	1	1	3	5	2	3
HEDERA HELIX 'HIBERNICA'	1	1	1	1	3	5	2	3
HEDERA HELIX 'TRICOLOR'	1	1	1	1	3	5	2	3
HELICHRYSUM SEROTINUM	3	1	4	1	2	2	3	3
HIBISCUS SYRIACUS 'BLUE BIRD'	3	3	4	1	3	3	2	3
HIBISCUS SYRIACUS 'HAMABO'	3	3	4	1	3	3	2	3

Plant Name.	T	D	M	P	C	E	L	S
HIBISCUS SYRIACUS 'WILLIAM R. SMITH'	3	3	4	1	3	3	2	3
HIBISCUS SYRIACUS 'WOODBRIDGE'	3	3	4	1	3	3	2	3
HIPPOPHAE RHAMNOIDES	1	1	4	1	2	5	2	3
HUMULUS LUPULUS 'AUREUS'	1	1	1	1	3	4	2	3
HYDRANGEA 'ALTONIA'	1	1	1	1	2	4	2	2
HYDRANGEA 'BLUE WAVE'	1	1	1	1	2	4	2	2
HYDRANGEA 'GENERALE VICOMTESSE DE VIBRAYE'	1	1	1	1	2	4	2	2
HYDRANGEA 'JOSEPH BANKS'	1	1	1	1	2	4	2	2
HYDRANGEA 'KING GEORGE'	1	1	1	1	2	4	2	2
HYDRANGEA 'MADAME EMILE MOUILLIERE'	1	1	1	1	2	4	2	2
HYDRANGEA 'PREZIOSA'	1	1	1	1	3	3	2	2
HYDRANGEA 'VEITCHII'	1	1	1	1	2	4	2	2
HYDRANGEA ARBORESCENS 'GRANDIFLORA'	1	1	1	1	3	4	2	2
HYDRANGEA HORTENSIS	1	1	1	1	2	4	2	2
HYDRANGEA PANICULATA 'GRANDIFLORA'	1	1	1	1	3	3	2	2
HYDRANGEA PETIOLARIS	1	1	1	1	3	4	2	3
HYDRANGEA QUERCIFOLIA	1	1	1	1	3	3	2	2
HYDRANGEA SARGENTIANA	1	1	1	1	3	3	2	2
HYDRANGEA SERRATA 'BLUEBIRD'	1	1	1	1	3	3	2	2
HYDRANGEA VILLOSA	1	1	1	1	3	3	2	2
HYPERICUM 'HIDCOTE'	1	1	4	1	3	4	2	3
HYPERICUM 'ROWALLANE'	1	1	4	1	3	2	3	3
HYPERICUM CALYCINUM	1	1	4	1	3	4	2	3
HYPERICUM X MOSERANUM	1	1	4	1	3	4	2	3

Plant Name.	T	D	M	P	C	E	L	S
HYPERICUM X MOSERANUM 'TRICOLOR'	1	1	4	1	3	4	2	3
ILEX AQUIFOLIUM	1	3	4	1	2	5	2	3
ILEX AQUIFOLIUM 'ARGENTEA MARGINATA'	1	3	4	1	2	5	2	3
ILEX AQUIFOLIUM 'BACCIFLAVA'	1	3	4	1	2	5	2	3
ILEX AQUIFOLIUM 'GOLDEN QUEEN'	1	3	4	1	2	5	2	3
ILEX AQUIFOLIUM 'HANDSWORTH NEW SILVER'	1	3	4	1	2	5	2	3
ILEX AQUIFOLIUM 'J.C. VAN TOL'	1	3	4	1	2	5	2	3
ILEX AQUIFOLIUM 'PYRAMIDALIS'	1	3	4	1	2	5	2	3
ILEX X ALTACLARENSIS 'CAMELLIIFOLIA'	1	3	4	1	2	4	2	3
ILEX X ALTACLARENSIS 'GOLDEN KING'	1	3	4	1	2	4	2	3
ILEX X ALTACLARENSIS 'HODGINSII'	1	3	4	1	2	4	2	3
ILEX X ALTACLARENSIS 'SILVER SENTINEL'	1	3	4	1	2	4	2	3
ITEA ILICIFOLIA	3	3	4	1	3	2	3	3
JASMINUM NUDIFLORUM	1	1	4	1	3	5	2	3
JASMINUM OFFICINALE 'AFFINE'	1	1	1	1	3	4	2	3
JASMINUM X STEPHANENSE	1	1	1	1	3	4	2	3
JUGLANS NIGRA	1	3	4	1	3	4	3	3
JUGLANS REGIA	1	3	4	1	3	4	3	3
JUNIPERUS 'GREY OWL'	1	1	4	1	2	5	2	3
JUNIPERUS COMMUNIS	1	1	4	1	2	5	2	3
JUNIPERUS COMMUNIS 'COMPRESSA'	1	1	4	1	2	5	2	3
JUNIPERUS COMMUNIS 'HIBURNICA'	1	1	4	1	2	5	2	3

Plant Name.	T	D	M	P	C	E	L	S
JUNIPERUS COMMUNIS 'HORNBROOKII'	1	1	4	1	2	5	2	3
JUNIPERUS COMMUNIS 'REPANDA'	1	1	4	1	2	5	2	3
JUNIPERUS CONFERTA	1	1	4	1	2	5	2	3
JUNIPERUS HORIZONTALIS 'PLUMOSA'	1	1	1	1	2	5	2	2
JUNIPERUS HORIZONTALIS 'WILTONII'	1	1	1	1	2	5	2	2
JUNIPERUS SQUAMATA 'BLUE STAR'	1	1	4	1	2	5	2	3
JUNIPERUS SQUAMATA 'MEYERI'	1	1	4	1	2	5	2	3
JUNIPERUS VIRGINIANA 'SKYROCKET'	1	1	4	1	2	5	2	3
JUNIPERUS X MEDIA 'OLD GOLD'	1	1	4	1	2	5	2	3
JUNIPERUS X MEDIA 'PFITZERANA'	1	1	4	1	2	5	2	3
JUNIPERUS X MEDIA 'PFITZERANA AUREA'	1	1	4	1	2	5	2	3
KALMIA LATIFOLIA	1	3	3	4	3	4	2	3
KERRIA JAPONICA	1	3	4	1	3	5	2	3
KERRIA JAPONICA 'PLENIFLORA'	1	3	4	1	3	4	2	3
KOELREUTERIA PANICULATA	1	3	4	1	3	4	2	3
KOLKWITZIA AMABILIS 'PINK CLOUD'	1	1	4	1	3	4	2	3
LABURNUM ALPINUM	1	1	1	1	3	4	2	3
LABURNUM X WATERERI 'VOSSII'	1	1	1	1	3	4	2	3
LARIX DECIDUA	1	3	4	4	3	5	2	3
LARIX KAEMPFERI	1	3	4	4	3	5	2	3
LAURUS NOBILIS	3	1	4	1	2	3	2	3
LAVANDULA SPICA 'HIDCOTE'	3	1	4	3	2	4	2	3
LAVANDULA SPICA 'MUNSTEAD'	3	1	4	3	2	4	2	3
LAVANDULA SPICA 'VERA'	3	1	4	3	2	4	2	3

Plant Name.	T	D	M	P	C	E	L	S
LAVATERA OLBIA	3	1	4	1	2	3	3	3
LEUCOTHOE FONTANESIANA	1	1	3	4	3	5	2	3
LEYCESTERIA FORMOSA	1	1	1	1	2	4	2	3
LIGUSTRUM JAPONICUM	1	1	1	1	3	5	2	3
LIGUSTRUM LUCIDUM	1	1	1	1	3	5	2	3
LIGUSTRUM OVALIFOLIUM	1	1	1	1	3	5	2	3
LIGUSTRUM OVALIFOLIUM 'AUREUM'	1	1	1	1	3	5	2	3
LIGUSTRUM VULGARE	1	1	1	1	3	5	2	3
LIQUIDAMBER STYRACIFLUA	1	3	4	4	3	4	2	3
LIRIODENDRON TULIPIFERA	1	3	4	3	3	4	2	3
LOMATIA MYRICOIDES	1	3	4	4	3	4	2	3
LONICERA ACUMINATA	1	1	4	1	3	4	2	3
LONICERA CAPRIFOLIUM	1	1	4	1	3	4	2	3
LONICERA ETRUSCA	1	1	4	1	2	4	2	3
LONICERA HENRYI	1	1	4	1	3	4	2	3
LONICERA JAPONICA 'AUREORETICULATA'	1	1	4	1	3	4	2	3
LONICERA JAPONICA 'HALLIANA'	1	1	4	1	3	4	2	3
LONICERA JAPONICA REPENS	1	1	4	1	3	4	2	3
LONICERA NITIDA 'ERNEST WILSON'	1	1	4	1	3	4	2	3
LONICERA NITIDA 'FERTILIS'	1	1	4	1	3	4	2	3
LONICERA PERICLYMENUM	1	1	4	1	3	4	2	3
LONICERA PERICLYMENUM 'SEROTINA'	1	1	4	1	3	4	2	3
LONICERA PILEATA	1	1	4	1	2	4	2	3
LONICERA SYRINGANTHA 'GRANDIFLORA'	1	1	4	1	3	4	2	3
LONICERA TRAGOPHYLLA	1	1	4	1	3	4	2	3

Plant Name.	T	D	M	P	C	E	L	S
LONICERA X AMERICANA	1	1	4	1	3	4	2	3
LONICERA X TELLMANNIANA	1	1	4	1	3	4	2	3
LONICERA X PURPUSII	1	1	4	1	3	4	2	3
LYCIUM CHINENSE	3	1	4	1	2	5	2	3
MAGNOLIA GRANDIFLORA 'EXMOUTH'	1	3	4	1	3	3	2	3
MAGNOLIA LILIIFLORA 'NIGRA'	1	3	4	4	3	3	3	3
MAGNOLIA LOEBNERI 'LEONARD MESSEL'	1	3	4	1	3	3	3	3
MAGNOLIA LOEBNERI 'MERRILL'	1	3	4	1	3	3	3	3
MAGNOLIA SINENSIS	1	3	4	1	3	3	2	3
MAGNOLIA STELLATA	1	1	4	1	3	4	3	3
MAGNOLIA X SOULANGIANA	1	3	4	4	3	3	3	3
MAGNOLIA X SOULANGIANA 'LENNEI'	1	3	4	4	3	3	3	3
MAGNOLIA X SOULANGIANA 'PICTURE'	1	3	4	4	3	3	3	3
MAHONIA 'CHARITY'	1	3	4	1	3	4	2	3
MAHONIA 'UNDULATA'	1	3	4	1	3	4	2	3
MAHONIA AQUIFOLIUM	1	3	4	1	3	4	2	3
MAHONIA JAPONICA	1	3	4	1	3	4	2	3
MAHONIA PINNATA	1	3	4	1	3	4	2	3
MALUS 'GOLDEN HORNET'	1	1	3	1	3	5	2	3
MALUS 'JOHN DOWNIE'	1	1	3	1	3	5	2	3
MALUS 'KATHERINE'	1	1	3	1	3	5	2	3
MALUS 'LISET'	1	1	3	1	3	5	2	3
MALUS 'PROFUSION'	1	1	3	2	3	5	2	3
MALUS 'RED JADE'	1	1	3	1	3	5	2	3
MALUS 'RED SENTINEL'	1	1	3	1	3	5	2	3
MALUS 'VAN ESELTINE'	1	1	3	1	3	5	2	3

Plant Name.	T	D	M	P	C	E	L	S
MALUS CORONARIA 'CHARLOTTAE'	1	1	3	1	3	5	2	3
MALUS FLORIBUNDA	1	1	3	1	3	5	2	3
MALUS HUPEHENSIS	1	1	3	1	3	5	2	3
MALUS SARGENTII	1	1	3	2	3	5	2	3
MALUS SYLVESTRIS	1	1	3	1	3	5	2	3
MALUS TSCHONOSKII	1	1	3	1	3	5	2	3
MALUS X ATROSANGUINEA	1	1	3	1	3	5	2	3
MESPILUS GERMANICA 'NOTTINGHAM'	1	1	4	1	3	5	2	3
METASEQUOIA GLYPTOSTOBOIDES	1	1	1	1	3	5	2	3
MORUS NIGRA	3	3	4	1	2	4	2	3
MYRICA GALE	4	1	3	4	3	5	2	2
MYRTUS COMMUNIS	1	3	4	1	2	3	2	3
NEILLIA THIBETICA	4	1	3	1	3	4	2	3
NOTHOFAGUS OBLIQUA	1	1	4	4	3	4	2	3
OLEARIA MACRODONTA 'MAJOR'	1	1	4	1	2	3	2	3
OLEARIA X HAASTII	1	1	4	1	2	3	2	3
OSMANTHUS DELAVAYI	1	1	4	1	3	4	2	3
OSMANTHUS HETEROPHYLLUS	1	1	4	1	3	4	2	3
OSMAREA 'BURKWOODII'	1	1	4	1	3	4	2	3
PACHYSANDRA TERMINALIS	1	3	1	4	3	4	2	3
PACHYSANDRA TERMINALIS 'VARIEGATA'	1	3	1	4	3	4	2	3
PAEONIA LUTEA LUDLOWII	1	1	4	1	3	4	3	3
PAEONIA DELAVAYI	1	1	4	1	3	4	3	3
PARROTIA PERSICA	1	1	4	1	3	4	2	3
PARTHENOCISSUS HENRYANA	1	1	4	1	3	4	2	3
PARTHENOCISSUS QUINQUEFOLIA	1	1	4	1	3	4	2	3
PARTHENOCISSUS TRICUSPIDATA	1	1	4	1	3	4	2	3

Plant Name.	T	D	M	P	C	E	L	S
PASSIFLORA CAERULEA	1	1	4	1	3	2	3	3
PAULOWNIA TOMENTOSA	1	3	4	1	3	4	3	3
PERNETTYA MUCRONATA 'BELL'S SEEDLING'	1	1	4	4	3	5	2	3
PERNETTYA MUCRONATA MALE	1	1	4	4	3	5	2	3
PEROVSKIA ATRIPLICIFOLIA 'BLUE SPIRE'	1	1	4	1	3	4	2	3
PHELLODENDRON AMURENSE	1	3	4	1	3	4	3	3
PHILADELPHUS 'BEAUCLERK'	1	1	4	1	3	4	2	3
PHILADELPHUS 'BELLE ETOILE'	1	1	4	1	3	4	2	3
PHILADELPHUS 'MNTEAU D'HERMINE'	1	1	4	1	3	4	2	3
PHILADELPHUS 'SYBILLE'	1	1	4	1	3	4	2	3
PHILADELPHUS 'VIRGINAL'	1	1	4	1	3	4	2	3
PHILADELPHUS MICROPHYLLUS	1	1	4	1	3	4	2	3
PHILLYREA DECORA	1	1	1	1	3	4	2	3
PHLOMIS FRUTICOSA	1	1	4	1	2	3	2	3
PHORMIUM 'BRONZE BABY'	1	1	1	1	2	4	2	3
PHORMIUM TENAX	1	1	1	1	2	4	2	3
PHOTINIA GLABRA 'RUBENS'	1	1	4	1	3	3	2	3
PHOTINIA X FRASERI 'ROBUSTA'	1	1	4	1	3	3	2	3
PICEA ABIES	1	3	3	4	3	4	2	3
PICEA ABIES 'CLANBRASSILLIANA'	1	3	3	4	3	4	2	3
PICEA ABIES 'NIDIFORMIS'	1	3	3	4	3	4	2	3
PICEA BREWERANA	1	3	3	4	3	4	2	3
PICEA GLAUCA ALBERTIANA 'CONICA'	1	3	3	4	3	5	2	3
PICEA MARIANA 'NANA'	1	3	3	4	3	4	2	3
PICEA OMORIKA	1	1	4	1	3	5	2	3

Plant Name.	T	D	M	P	C	E	L	S
PICEA PUNGENS 'KOSTER'	1	1	4	1	3	4	2	3
PIERIS 'FOREST FLAME'	1	1	4	4	3	4	3	3
PIERIS FORMOSA 'WAKEHURST'	1	1	4	4	3	4	3	3
PIERIS JAPONICA 'VARIEGATA'	1	1	4	4	3	4	3	3
PIERIS TAIWANENSIS	1	1	4	4	3	4	3	3
PILEOSTEGIA VIBURNOIDES	1	1	4	1	3	4	2	3
PINUS CEMBRA	1	1	4	1	3	5	2	3
PINUS CONTORTA	3	1	4	4	2	5	2	3
PINUS MUGO	1	1	4	1	2	5	2	3
PINUS NIGRA	1	1	4	1	2	5	2	3
PINUS NIGRA MARITIMA	1	1	4	1	2	5	2	3
PINUS PARVIFLORA	1	1	4	1	3	4	2	3
PINUS SYLVESTRIS	1	3	4	4	3	5	2	3
PINUS SYLVESTRIS 'BEUVRONENSIS'	1	3	4	4	3	5	2	3
PINUS WALLICHIANA	1	3	4	4	3	4	2	3
PITTOSPORUM TENUIFOLIUM	1	1	4	1	2	3	2	3
PITTOSPORUM TENUIFOLIUM 'SILVER QUEEN'	1	1	4	1	2	3	2	3
PLATANUS X HISPANICA	1	3	4	4	3	5	2	3
POLYGONUM BALDSCHUANICUM	1	1	4	1	2	4	2	3
POPULUS 'ROBUSTA'	1	1	1	1	3	5	2	2
POPULUS ALBA	1	1	1	1	2	5	2	2
POPULUS CANESCENS	1	1	1	1	2	5	2	2
POPULUS NIGRA	1	1	1	1	3	5	2	2
POPULUS NIGRA 'ITALICA'	1	1	1	1	3	5	2	2
POPULUS NIGRA BETULIFOLIA	1	1	1	1	3	5	2	2
POPULUS TACAMAHACA	1	1	1	1	3	5	2	2
POPULUS TREMULA	1	1	1	1	2	5	2	2

Plant Name.	T	D	M	P	C	E	L	S
POPULUS X CANDICANS	1	1	1	1	3	5	2	2
POTENTILLA 'ELIZABETH'	1	1	4	1	3	4	2	3
POTENTILLA 'KATHERINE DYKES'	1	1	4	1	3	4	2	3
POTENTILLA 'LONGACRE'	1	1	4	1	3	4	2	3
POTENTILLA 'PRIMROSE BEAUTY'	1	1	4	1	3	4	2	3
POTENTILLA 'SUNSET'	1	1	4	1	3	4	2	3
POTENTILLA ARBUSCULA 'BEESII'	1	1	4	1	3	4	2	3
POTENTILLA DAHURICA 'MANCHU'	1	1	4	1	3	4	2	3
POTENTILLA PARVIFOLIA 'KLONDYKE'	1	1	4	1	3	4	2	3
PRUNUS 'AMANOGAWA'	1	1	4	1	3	4	2	3
PRUNUS 'CISTENA'	1	1	4	1	3	4	2	3
PRUNUS 'HALLY JOLIVETTE'	1	1	4	1	3	4	2	3
PRUNUS 'KANZAN'	1	1	4	1	3	4	2	3
PRUNUS 'KIKU-SHIDARE SAKURA'	1	1	4	1	3	4	2	3
PRUNUS 'OKAME'	1	1	4	1	3	4	2	3
PRUNUS 'PANDORA'	1	1	4	1	3	4	2	3
PRUNUS 'PINK PERFECTION'	1	1	4	1	3	4	2	3
PRUNUS 'SHIMIDSU SAKURA'	1	1	4	1	3	4	2	3
PRUNUS 'SHIROFUGEN'	1	1	4	1	3	4	2	3
PRUNUS 'SHIROTAE'	1	1	4	1	3	4	2	3
PRUNUS 'TAI HAKU'	1	1	4	1	3	4	2	3
PRUNUS 'UKON'	1	1	4	1	3	4	2	3
PRUNUS 'UMINEKO'	1	1	4	1	3	4	2	3
PRUNUS AVIUM	1	1	4	1	3	4	2	3
PRUNUS AVIUM 'PLENA'	1	1	4	1	3	4	2	3
PRUNUS CERASIFERA 'NIGRA'	1	1	4	1	3	4	2	3
PRUNUS CERASIFERA 'PISSARDII'	1	1	4	1	3	4	2	3

Plant Name.	T	D	M	P	C	E	L	S
PRUNUS DULCIS	1	1	4	1	3	4	2	3
PRUNUS LAUROCERASUS 'OTTO LUYKEN'	1	3	4	4	3	4	2	3
PRUNUS LAUROCERASUS 'ROTUNDIFOLIA'	1	3	4	4	3	4	2	3
PRUNUS LAUROCERASUS 'ZABELIANA'	1	3	4	4	3	4	2	3
PRUNUS LUSITANICA	1	1	4	1	3	4	2	3
PRUNUS LUSITANICA AZORICA	1	1	4	1	3	4	2	3
PRUNUS PADUS 'WATERERI'	1	1	4	1	3	4	2	3
PRUNUS SARGENTII	1	1	4	1	3	4	2	3
PRUNUS SERRULA	1	1	4	1	3	4	2	3
PRUNUS SPINOSA	1	1	4	1	2	4	2	3
PRUNUS SPINOSA 'PURPUREA'	1	1	4	1	2	4	2	3
PRUNUS SUBHIRTELLA 'AUTUMNALIS'	1	1	4	1	3	4	2	3
PRUNUS TENELLA	1	1	4	1	3	4	2	3
PRUNUS TENELLA 'FIRE HILL'	1	1	4	1	3	4	2	3
PRUNUS X AMAGDALO-PERSICA 'POLLARDII'	1	1	4	1	3	4	2	3
PRUNUS X BLIREANA	1	1	4	1	3	4	2	3
PRUNUS X HILLIERI 'SPIRE'	1	1	4	1	3	4	2	3
PRUNUS X SCHMITTII	1	1	4	1	3	4	2	3
PRUNUS X YEDOENSIS	1	1	4	1	3	4	2	3
PSEUDOTSUGA MENZIESII	1	3	4	4	3	5	2	3
PTELEA TRIFOLIATA	1	1	4	1	3	4	2	3
PTEROCARYA FRAXINIFOLIA	1	1	1	1	3	4	2	2
PYRACANTHA 'ORANGE GLOW'	1	1	4	1	2	5	2	3
PYRACANTHA ATALANTIOIDES	1	1	4	1	2	5	2	3
PYRACANTHA ATALANTIOIDES 'AUREA'	1	1	4	1	2	5	2	3

Plant Name.	T	D	M	P	C	E	L	S
PYRACANTHA COCCINEA 'LALANDEI'	1	1	4	1	2	5	2	3
PYRACANTHA ROGERSIANA	1	1	4	1	2	5	2	3
PYRACANTHA ROGERSIANA 'FLAVA'	1	1	4	1	2	5	2	3
PYRUS BETULIFOLIA	1	1	1	1	3	5	2	3
PYRUS CALLERYANA 'CHANTICLEER'	1	1	1	1	3	5	2	3
PYRUS COMMUNIS	1	1	1	1	3	5	2	3
PYRUS COMMUNIS 'BEECH HILL'	1	1	1	1	3	5	2	3
PYRUS NIVALIS	1	1	1	1	3	5	2	3
PYRUS SALICIFOLIA 'PENDULA'	1	1	1	1	3	5	2	3
QUERCUS CASTANEIFOLIA 'GREEN SPIRE'	1	3	4	1	3	5	2	3
QUERCUS CERRIS	1	3	4	1	2	5	2	3
QUERCUS ILEX	1	3	4	1	2	4	2	3
QUERCUS PALUSTRIS	1	3	4	1	3	4	2	3
QUERCUS PETRAEA	1	3	1	1	2	5	2	3
QUERCUS ROBUR	1	3	4	1	2	5	2	3
QUERCUS ROBUR 'FASTIGIATA'	1	3	4	1	2	5	2	3
QUERCUS RUBRA	1	3	4	1	3	5	2	3
RHAMNUS ALATERNA	1	1	1	1	2	4	2	3
RHAMNUS ALATERNA 'ARGENTEOVARIEGATA'	1	1	1	1	2	4	2	3
RHAMNUS CATHARTICA	1	1	1	1	3	5	2	3
RHAMNUS FRANGULA	1	1	1	1	3	4	2	3
RHODODENDRON 'BETTY WORMALD'	1	1	4	4	3	4	2	3
RHODODENDRON 'BLUE DIAMOND'	1	1	4	4	3	4	3	3
RHODODENDRON 'BLUE PETER'	1	1	4	4	3	4	2	3
RHODODENDRON 'BO-PEEP'	1	1	4	4	3	4	2	3
RHODODENDRON 'BOW BELLS'	1	1	4	4	3	4	2	3

Plant Name.	T	D	M	P	C	E	L	S
RHODODENDRON 'BRIC-A-BRAC'	1	1	4	4	3	4	2	3
RHODODENDRON 'BRITTANIA'	1	1	4	4	3	4	2	3
RHODODENDRON 'CHIKOR'	1	1	4	4	3	4	2	3
RHODODENDRON 'CORONA'	1	1	4	4	3	4	2	3
RHODODENDRON 'COWSLIP'	1	1	4	4	3	4	2	3
RHODODENDRON 'CYNTHIA'	1	1	4	4	3	4	2	3
RHODODENDRON 'EARL OF ATHLONE'	1	1	4	4	3	4	2	3
RHODODENDRON 'ELIZABETH'	1	1	4	4	3	4	2	3
RHODODENDRON 'FABIA'	1	1	4	4	3	4	2	3
RHODODENDRON 'FASTUOSUM FLORE PLENO'	1	1	4	4	3	4	2	3
RHODODENDRON 'FURNIVAL'S DAUGHTER'	1	1	4	4	3	4	2	3
RHODODENDRON 'GOLDSWORTH YELLOW'	1	1	4	4	3	4	2	3
RHODODENDRON 'GOMER WATERER'	1	1	4	4	3	4	2	3
RHODODENDRON 'JENNY'	1	1	4	4	3	4	2	3
RHODODENDRON 'LAVENDER GIRL'	1	1	4	4	3	4	2	3
RHODODENDRON 'LODER'S WHITE'	1	1	4	4	3	4	2	3
RHODODENDRON 'MAY DAY'	1	1	4	4	3	4	2	3
RHODODENDRON 'MRS. CHARLES E. PEARSON'	1	1	4	4	3	4	2	3
RHODODENDRON 'MRS. G.W. LEAK'	1	1	4	4	3	4	2	3
RHODODENDRON 'NOBLEANUM'	1	1	4	4	3	4	2	3
RHODODENDRON 'PINK PEARL'	1	1	4	4	3	4	2	3
RHODODENDRON 'PRAECOX'	1	1	4	4	3	4	2	3
RHODODENDRON 'PURPLE SPLENDOUR'	1	1	4	4	3	4	2	3
RHODODENDRON 'SAPPHO'	1	1	4	4	3	4	2	3
RHODODENDRON 'SCARLET WONDER'	1	1	4	4	3	4	2	3

Plant Name.	T	D	M	P	C	E	L	S
RHODODENDRON 'SETA'	1	1	4	4	3	4	2	3
RHODODENDRON 'SOUVENIR DE DR. S. ENDTZ'	1	1	4	4	3	4	2	3
RHODODENDRON 'SUSAN'	1	1	4	4	3	4	2	3
RHODODENDRON 'TESSA'	1	1	4	4	3	4	2	3
RHODODENDRON 'VANESSA'	1	1	4	4	3	4	2	3
RHODODENDRON 'WINSOME'	1	1	4	4	3	4	2	3
RHODODENDRON 'YELLOW HAMMER'	1	1	4	4	3	4	2	3
RHODODENDRON AUGUSTINII	1	1	4	4	3	4	2	3
RHODODENDRON CALOSTROTUM 'GIGHA'	1	1	4	4	3	4	2	3
RHODODENDRON CAMPYLOGYNUM	1	1	4	4	3	4	2	3
RHODODENDRON FASTIGATUM	1	1	4	4	3	4	2	3
RHODODENDRON FORRESTII REPENS	1	1	3	4	3	4	2	3
RHODODENDRON IMPEDITUM	1	1	4	4	3	4	2	3
RHODODENDRON LUTEUM	1	3	4	4	3	4	2	3
RHODODENDRON OBTUSUM 'AMOENUM'	1	1	4	4	3	4	2	3
RHODODENDRON PEMAKOENSE	1	1	4	4	3	4	2	3
RHODODENDRON PONTICUM	1	1	4	4	3	5	2	3
RHODODENDRON SCINTILLANS	1	1	4	4	3	4	2	3
RHODODENDRON WILLIAMSIANUM	1	1	4	4	3	4	2	3
RHODODENDRON YAKUSHIMANUM	1	1	1	4	3	4	2	3
RHUS TAPHINA	1	1	1	1	3	4	2	3
RHUS TYPHINA 'LACINIATA'	1	1	1	1	3	4	2	3
RIBES ODORATUM	1	1	1	1	3	5	2	3
RIBES SANGUINEUM 'PULBOROUGH SCARLET'	1	1	1	1	3	5	2	3
ROBINIA PSEUDOACACIA	1	1	1	1	3	5	2	3

Plant Name.	T	D	M	P	C	E	L	S
ROBINIA PSEUDOACACIA 'BESSONIANA'	1	1	1	1	3	5	2	3
ROBINIA PSEUDOACACIA 'FRISIA'	1	1	1	1	3	5	2	3
ROBINIA PSEUDOACACIA 'PYRAMIDALIS'	1	1	1	1	3	5	2	3
ROBINIA X HILLIERI	1	1	1	1	3	5	2	3
ROMNEYA COULTERI	1	3	4	1	3	4	2	3
ROSMARINUS OFFICINALIS	1	1	4	1	2	4	2	3
ROSMARINUS OFFICINALIS 'SEVERN SEA'	1	1	4	1	2	4	2	3
ROSA 'BALLERINA'	1	1	4	3	3	4	2	3
ROSA 'CERISE BOUQUET'	1	1	4	3	3	4	2	3
ROSA 'FRUHLINGSGOLD'	1	1	4	3	3	4	2	3
ROSA 'FRUHLINSMORGEN'	1	1	4	3	3	4	2	3
ROSA 'KASSEL'	1	1	4	3	3	4	2	3
ROSA 'MARGUERITE HILLING'	1	1	4	3	3	4	2	3
ROSA 'MOZOMI'	1	1	4	3	3	4	2	3
ROSA 'NEVADA'	1	1	4	3	3	4	2	3
ROSA 'SCARLET FIRE'	1	1	4	3	3	4	2	3
ROSA 'THE FAIRY'	1	1	4	3	3	4	2	3
ROSA 'YESTERDAY'	1	1	4	3	3	4	2	3
ROSA CANINA	1	1	4	3	3	4	2	3
ROSA FILIPES 'KIFTSGATE'	1	1	4	3	3	4	2	3
ROSA GALLICA 'COMPLICATA'	1	1	4	3	3	4	2	3
ROSA GALLICA 'ROSAMUNDI'	1	1	4	3	3	4	2	3
ROSA HUGONIS	1	1	4	3	3	4	2	3
ROSA HYBRID MUSK 'BUFF BEAUTY'	1	1	4	3	3	4	2	3
ROSA HYBRID MUSK 'CORNELIA'	1	1	4	3	3	4	2	3
ROSA HYBRID MUSK 'FELICIA'	1	1	4	3	3	4	2	3

Plant Name.	T	D	M	P	C	E	L	S
ROSA HYBRID MUSK 'PENELOPE'	1	1	4	3	3	4	2	3
ROSA MACROPHYLLA	1	1	4	3	3	4	2	3
ROSA MOYESII 'GERANIUM'	1	1	4	3	3	4	2	3
ROSA NITIDA	1	1	4	3	3	4	2	3
ROSA OMEIENSIS PTEROCANTHA	1	1	4	3	3	4	2	3
ROSA PAULII	1	1	4	3	3	4	2	3
ROSA PIMPINELLIFOLIA	1	1	4	3	3	4	2	3
ROSA ROXBURGHII	1	1	4	3	3	4	2	3
ROSA RUBIGINOSA	1	1	4	3	3	4	2	3
ROSA RUBRIFOLIA	1	1	4	3	3	4	2	3
ROSA RUGOSA 'BLANC DOUBLE DE COUBERT'	1	1	4	3	2	4	2	3
ROSA RUGOSA 'FRAU DAGMAR HASTRUP'	1	1	4	3	2	4	2	3
ROSA RUGOSA 'MAX GRAF'	1	1	4	3	2	4	2	3
ROSA RUGOSA 'ROSERAIE DE L'HAY'	1	1	4	3	2	4	2	3
ROSA RUGOSA 'RUBRA'	1	1	4	3	2	4	2	3
ROSA RUGOSA 'SCABROSA'	1	1	4	3	2	4	2	3
ROSA RUGOSA ALBA	1	1	4	3	2	4	2	3
ROSA SWEGINZOWII	1	1	4	3	3	4	2	3
ROSA WILLMOTTIAE	1	1	4	3	3	4	2	3
ROSA XANTHINA 'CANARY BIRD'	1	1	4	3	3	4	2	3
RUBUS CAESIUS	1	1	1	1	3	5	2	3
RUBUS CALYCINOIDES	1	1	1	1	3	5	2	3
RUBUS COCKBURNIANUS	1	1	1	1	3	5	2	3
RUBUS FRUTICOSA	1	1	1	1	3	5	2	3
RUBUS TRICOLOR	1	1	1	1	3	5	2	3
RUBUS TRIDEL 'BENENDEN'	1	1	1	1	3	5	2	3

Plant Name.	T	D	M	P	C	E	L	S
RUSCUS ACULEATUS	1	1	4	1	3	5	2	3
RUTA GRAVEOLENS 'JACKMAN'S BLUE'	1	1	4	1	3	4	2	3
SALIX 'CAERULEA'	1	1	1	1	2	5	2	2
SALIX ALBA	1	1	1	1	2	5	2	2
SALIX ALBA 'CHERMESINA'	1	1	1	1	2	5	2	2
SALIX ALBA 'SERICEA'	1	1	1	1	2	5	2	2
SALIX ALBA 'VITELLINA'	1	1	1	1	2	5	2	2
SALIX CAPREA	1	1	1	1	2	5	2	2
SALIX CINEREA	1	1	1	1	2	5	2	2
SALIX DAPHNOIDES	1	1	1	1	2	5	2	2
SALIX ELAEAGNOS	1	1	1	1	2	5	2	2
SALIX FRAGILIS	1	1	1	1	2	5	2	2
SALIX GRACILISTYLA	1	1	1	1	2	5	2	2
SALIX HASTATA 'WEHRHAHNII'	1	1	1	1	2	5	2	2
SALIX MATSUDANA 'PENDULA'	1	1	1	1	2	5	2	2
SALIX MATSUDANA 'TORTUOSA'	1	1	1	1	2	5	2	2
SALIX PENTANDRA	1	1	1	1	2	5	2	2
SALIX PURPUREA	1	1	1	1	2	5	2	2
SALIX PURPUREA 'GRACILIS'	1	1	1	1	2	5	2	2
SALIX PURPUREA 'PENDULA'	1	1	1	1	2	5	2	2
SALIX REPENS ARGENTEA	1	1	1	1	2	5	2	2
SALIX VIMINALIS	1	1	1	1	2	5	2	2
SALIX X CHRYSOCOMA	1	1	1	1	2	5	2	2
SALVIA OFFICINALIS 'ICTERINA'	3	1	4	1	3	2	3	3
SALVIA OFFICINALIS 'PURPURASCENS'	3	1	4	1	3	2	3	3
SAMBUCUS CANADENSIS 'MAXIMA'	1	1	1	1	3	4	2	3
SAMBUCUS NIGRA	1	1	1	1	3	4	2	3

Plant Name.	T	D	M	P	C	E	L	S
SAMBUCUS NIGRA 'AUREA'	1	1	1	1	3	4	2	3
SAMBUCUS RACEMOSA 'PLUMOSA AUREA'	1	1	1	1	2	4	2	3
SANTOLINA CHAMAECYPARISSUS	3	1	4	1	2	4	2	3
SARCOCOCCA CONFUSA	1	1	1	1	3	5	2	3
SARCOCOCCA HOOKERANA DIGYNA	1	1	1	1	3	5	2	3
SARCOCOCCA HUMILIS	1	1	1	1	3	5	2	3
SCHIZOPHRAGMA INTEGRIFOLIUM	1	1	4	1	3	4	2	3
SENECIO GREYI	1	1	4	1	2	3	2	3
SENECIO MONROI	1	1	4	1	2	3	2	3
SEQUOIADENDRON GIGANTEUM	1	3	4	4	3	4	2	3
SEQUOIA SEMPERVIRENS	1	1	1	1	3	5	2	3
SKIMMIA JAPONICA 'FOREMANII'	1	1	1	1	2	4	2	3
SKIMMIA JAPONICA 'RUBELLA'	1	1	1	1	2	4	2	3
SOLANUM CRISPUM 'GLASNEVIN'	1	1	4	1	2	2	2	3
SOPHORA JAPONICA	3	1	4	1	3	4	2	3
SORBARIA AITCHISONII	1	1	4	1	3	4	2	3
SORBUS 'EMBLEY'	1	1	1	1	3	4	2	3
SORBUS 'JOSEPH ROCK'	1	1	1	1	3	5	2	3
SORBUS 'MITCHELLII'	1	1	1	1	3	4	2	3
SORBUS 'PEARLY KING'	1	1	1	1	3	4	2	3
SORBUS ARIA	1	1	4	1	2	4	2	3
SORBUS ARIA 'DECAISNEANA'	1	1	4	1	2	4	2	3
SORBUS ARIA 'LUTESCENS'	1	1	4	1	2	4	2	3
SORBUS AUCUPARIA	1	3	4	4	2	5	2	3
SORBUS AUCUPARIA 'FASTIGIATA'	1	3	4	4	2	5	2	3
SORBUS AUCUPARIA 'SHEERWATER SEEDLING'	1	3	4	4	2	5	2	3
SORBUS CUSPIDATA	1	1	4	1	3	4	2	3

Plant Name.	T	D	M	P	C	E	L	S
SORBUS DOMESTICA	1	1	4	1	3	4	2	3
SORBUS FOLGNERI	1	1	1	1	3	4	2	3
SORBUS HUPEHENSIS	1	1	1	1	3	4	2	3
SORBUS INTERMEDIA	1	1	1	1	3	4	2	3
SORBUS SARGENTIANA	1	1	1	1	3	4	2	3
SORBUS SCALARIS	1	1	1	1	3	4	2	3
SORBUS TORMINALIS	1	1	1	1	3	5	2	3
SORBUS X KEWENSIS	1	1	1	1	3	4	2	3
SORBUS X THURINGIACA 'FASTIGIATA'	1	1	1	1	3	4	2	3
SPARTIUM JUNCIUM	1	1	4	1	2	4	2	3
SPIRAEA JAPONICA 'ALPINA'	1	1	4	1	2	4	2	3
SPIRAEA NIPPONICA TOSAENSIS	1	1	4	1	2	4	2	3
SPIRAEA X ARGUTA	1	1	4	1	2	4	2	3
SPIRAEA X BUMALDA 'ANTHONY WATERER'	1	1	4	1	2	4	2	3
SPIRAEA X CINEREA 'GREFSHEIM'	1	1	4	1	2	4	2	3
STEPHANANDRA INCISA	1	1	1	1	3	4	2	3
STEPHANANDRA INCISA 'CRISPA'	1	1	1	1	3	5	2	3
STEWARTIA PSEUDOCAMELLIA	4	3	4	4	3	4	2	3
STRANVAESIA DAVIDIANA	1	1	4	1	3	4	2	3
STYRAX JAPONICA	4	1	3	4	3	4	2	3
SYMPHORICARPOS ALBUS	1	1	1	1	3	4	2	3
SYMPHORICARPOS X CHENAULTII 'HANCOCK'	1	1	1	1	3	4	2	3
SYMPHORICARPOS X DOORENBOSII 'WHITE EDGE'	1	1	1	1	3	4	2	3
SYRINGA 'CHARLES JOLY'	1	1	4	1	3	4	2	3
SYRINGA 'FIRMAMENT'	1	1	4	1	3	4	2	3
SYRINGA 'KATHERINE HAVEMEYER'	1	1	4	1	3	4	2	3

Plant Name.	T	D	M	P	C	E	L	S
SYRINGA 'MADAME ANTOINE BUCHNER'	1	1	4	1	3	4	2	3
SYRINGA 'MADAME LEMOINE'	1	1	4	1	3	4	2	3
SYRINGA 'MASSENA'	1	1	4	1	3	4	2	3
SYRINGA 'MAUD NOTCUTT'	1	1	4	1	3	4	2	3
SYRINGA 'MICHEL BUCHNER'	1	1	4	1	3	4	2	3
SYRINGA 'MRS. EDWARD HARDING'	1	1	4	1	3	4	2	3
SYRINGA 'SOUVENIR DE LOUIS SPAETH'	1	1	4	1	3	4	2	3
SYRINGA MICROPHYLLA 'SUPERBA'	1	1	4	1	3	4	2	3
SYRINGA VELUTINA	1	1	4	1	3	4	2	3
SYRINGA YUNNANENSIS	1	1	4	1	3	4	2	3
SYRINGA X JOSIFLEXA 'BELLICENT'	1	1	4	1	3	4	2	3
SYRINGA X PRESTONIAE 'ELINOR'	1	1	4	1	3	4	2	3
SYRINGA X PRESTONIAE 'ISABELLA'	1	1	4	1	3	4	2	3
TAMARIX GALLICA	1	3	4	4	2	5	2	3
TAMARIX PARVIFLORA	1	3	4	4	2	5	2	3
TAMARIX PENTANDRA	1	3	4	4	2	5	2	3
TAMARIX PENTANDRA 'RUBRA'	1	3	4	4	2	5	2	3
TAXODIUM DISTICHUM	1	1	1	4	3	4	2	2
TAXUS BACCATA	1	1	1	1	3	5	2	3
TAXUS BACCATA 'ELEGANTISSIMA'	1	1	1	1	3	5	2	3
TAXUS BACCATA 'FASTIGIATA'	1	1	1	1	3	5	2	3
TAXUS BACCATA 'FASTIGIATA AUREOMARGINATA'	1	1	1	1	3	5	2	3
TAXUS BACCATA 'REPANDANS'	1	1	1	1	3	5	2	3
THUJA OCCIDENTALIS	1	1	4	1	3	5	2	3
THUJA OCCIDENTALIS 'RHEINGOLD'	1	1	4	1	3	5	2	3

Plant Name.	T	D	M	P	C	E	L	S
THUJA ORIENTALIS 'AUREA NANA'	1	1	4	1	3	5	2	3
THUJA PLICATA	1	1	4	1	3	5	2	3
THUJA PLICATA 'FASTIGIATA'	1	1	4	1	3	5	2	3
THUJA PLICATA 'ZEBRINA'	1	1	4	1	3	5	2	3
TILIA CORDATA	1	1	1	1	3	5	2	3
TILIA MONGOLICA	1	1	1	1	3	5	2	3
TILIA PETIOLARIS	1	1	1	1	3	5	2	3
TILIA PLATYPHYLLOS 'RUBRA'	1	1	1	1	3	5	2	3
TILIA TOMENTOSA	1	1	1	1	3	5	2	3
TILIA X EUCHLORA	1	1	1	1	3	5	2	3
TSUGA CANADENSIS	3	3	4	1	3	5	2	3
TSUGA HETEROPHYLLA	3	3	4	4	3	5	2	3
ULEX EUROPAEUS	1	1	4	1	2	5	2	3
ULEX EUROPAEUS 'PLENUS'	1	1	4	1	2	5	2	3
ULEX GALLII	1	1	4	1	2	5	2	3
ULEX MINOR	1	1	4	1	2	5	2	3
VACCINIUM CORYMBOSUM	1	1	3	4	3	5	2	2
VACCINIUM VITIS-IDAEA	1	1	3	4	3	5	2	2
VIBURNUM BETULIFOLIUM	1	1	1	1	3	4	2	3
VIBURNUM DAVIDII	1	1	1	1	2	4	2	3
VIBURNUM FARRERI	1	1	1	1	3	4	2	3
VIBURNUM FARRERI CANDIDISSIMUM	1	1	1	1	3	4	2	3
VIBURNUM LANTANA	1	1	1	1	3	4	2	3
VIBURNUM OPULUS	1	1	1	1	2	4	2	3
VIBURNUM OPULUS 'NOTCUTT'S VARIETY'	1	1	1	1	2	4	2	3
VIBURNUM PLICATUM	1	1	1	1	2	4	2	3
VIBURNUM PLICATUM 'MARIESII'	1	1	1	1	2	4	2	3

Plant Name.	T	D	M	P	C	E	L	S
VIBURNUM PLICATUM 'PINK BEAUTY'	1	1	1	1	2	4	2	3
VIBURNUM RHYTIDOPHYLLUM	1	1	1	1	2	4	2	3
VIBURNUM TINUS	1	1	1	1	2	4	2	3
VIBURNUM TINUS 'EVE PRICE'	1	1	1	1	2	4	2	3
VIBURNUM X BODNANTENSE 'DAWN'	1	1	1	1	3	4	2	3
VIBURNUM X BURKWOODII	1	1	1	1	3	4	2	3
VIBURNUM X CARLCEPHALUM	1	1	1	1	3	4	2	3
VIBURNUM X JUDDII	1	1	1	1	3	4	2	3
VINCA MAJOR	1	1	1	1	3	4	2	3
VINCA MAJOR 'VARIEGATA'	1	1	1	1	3	4	2	3
VINCA MINOR	1	1	1	1	3	4	2	3
VINCA MINOR 'ALBA'	1	1	1	1	3	4	2	3
VINCA MINOR 'ATROPURPUREA'	1	1	1	1	3	4	2	3
VINCA MINOR 'BOWLES' VARIETY'	1	1	1	1	3	4	2	3
VINCA MINOR 'VARIEGATA'	1	1	1	1	3	4	2	3
VITIS 'BRANT'	1	1	4	1	3	4	2	3
VITIS COIGNETIAE	1	1	4	1	3	4	2	3
VITIS VINIFERA 'PURPUREA'	1	1	4	1	3	4	2	3
WEIGELA 'ABEL CARRIERE'	1	1	1	1	3	4	2	3
WEIGELA 'BRISTOL RUBY'	1	1	1	1	3	4	2	3
WEIGELA FLORIDA 'FOLIIS PURPUREIS'	1	1	1	1	3	4	2	3
WEIGELA FLORIDA 'VARIEGATA'	1	1	1	1	3	4	2	3
WEIGELA MIDDENDORFFIANA	1	1	1	1	3	4	2	3
WISTERIA SINENSIS	1	3	4	3	3	4	2	3
WISTERIA SINENSIS 'ALBA'	1	3	4	3	3	4	2	3
YUCCA FILAMENTOSA	1	1	4	1	2	4	2	3

Plant Name.	T	D	M	P	C	E	L	S
YUCCA FILAMENTOSA 'VARIEGATA'	1	1	4	1	2	4	2	3
YUCCA FLACCIDA 'IVORY'	1	1	4	1	2	4	2	3
YUCCA GLORIOSA	1	1	4	1	2	4	2	3
ZELKOVA SERRATA	1	3	3	1	3	4	2	3
X CUPRESSOCYPARIS LEYLANDII	1	1	1	1	2	5	2	3
X CUPRESSOCYPARIS LEYLANDII 'CASTLEWELLAN'	1	1	1	1	2	5	2	3
X FATSHEDERA LIZEI	1	1	4	1	2	2	3	3

APPENDIX E

SOIL SURVEY FILE CODING DATA

SOIL SURVEY AND ASSESSMENT PROGRAM CODES

PROGRAM FILE NUMBER	MAP SYMBOL & SUB GROUP	SOIL ASSOCIATION
1	22	UNRIPENED GLEY SOILS
2	311a	REVIDGE
3	311b	SKIDDAW
4	311c	WETTON 1
5	311d	WETTON 2
6	311e	BANGOR
7	313a	DUNWELL
8	313b	POWYS
9	313c	CRWBIN
10	341	ICKNIELD
11	342a	UPTON 1
12	342b	UPTON 2
13	342c	WANTAGE 1
14	342d	WANTAGE 2
15	343a	ELMTON 1
16	343b	ELMTON 2
17	343c	Elmton 3
18	343d	SHERBORNE
19	343e	MARCHAM
20	343f	NEWMARKET 1
21	343g	Newmarket 2
22	343h	ANDOVER 1
23	343i	ANDOVER 2
24	346	Reach
25	361	Sandwich
26	372	Willingham

PROGRAM FILE NUMBER	MAP SYMBOL & SUB GROUP	SOIL ASSOCIATION
27	411a	Evesham 1
28	411b	EVESHAM 2
29	411c	EVESHAM 3
30	411d	HANSLOPE
31	421a	STOW
32	421b	HALSTOW
33	431	WORCESTER
34	511a	ABERFORD
35	511b	Moreton
36	511c	PANHOLES
37	511d	Blewbury
38	511e	SWAFFHAM PRIOR
39	511f	COOMBE 1
40	511g	COOMBE 2
41	511h	BADSEY 1
42	511i	BADSEY 2
43	511j	STRETHAM
44	512a	ASWARBY
45	512b	LANDBEACH
46	512c	RUSKINGTON
47	512d	GROVE
48	512e	BLOCK
49	512f	Milton
50	513	CANNAMORE
51	521	METHWOLD
52	532a	BLACKTOFT
53	532b	ROMNEY

PROGRAM FILE NUMBER	MAP SYMBOL & SUB GROUP	SOIL ASSOCIATION
54	541a	MILFORD
55	541b	BROMSGROVE
56	541c	EARDISTON 1
57	541d	EARDISTON 2
58	541e	CREDITON
59	541f	RIVINGTON 1
60	541g	RIVINGTON 2
61	541h	NEATH
62	541i	MUNSLOW
63	541j	DENBIGH 1
64	541k	DENBIGH 2
65	541l	BARTON
66	541m	SOUTH PETHERTON
67	541n	Trusham
68	541o	MALHAM 1
69	541p	MALHAM 2
70	541q	WALTHAM
71	541r	WICK 1
72	541s	WICK 2
73	541t	WICK 3
74	541u	ELLERBECK
75	541v	RHEIDOL
76	541w	Newnham
77	541x	EAST KESWICK 1
78	541y	EAST KESWICK 2
79	541z	EAST KESWICK 3
80	541A	BEARSTED 1

PROGRAM FILE NUMBER	MAP SYMBOL & SUB GROUP	SOIL ASSOCIATION
81	541B	BEARSTED 2
82	541C	NEWBIGGIN
83	541D	OGLETHORPE
84	542	NERCWYS
85	543	ARROW
86	544	BANBURY
87	551a	BRIDGNORTH
88	551b	CUCKNEY 1
89	551c	CUCKNEY 2
90	551d	NEWPORT 1
91	551e	NEWPORT 2
92	551f	Newport 3
93	551g	NEWPORT 4
94	552a	KEXBY
95	552b	Ollerton
96	554a	FRILFORD
97	554b	WORLINGTON
98	555	Downham
99	561a	WHARFE
100	561b	TEME
101	561c	ALUN
102	561d	LUGWARDINE
103	571a	STON EASTON
104	571b	BROMYARD
105	571c	MALLING
106	571d	FYFIELD 1
107	571e	FYFIELD 2

PROGRAM FILE NUMBER	MAP SYMBOL & SUB GROUP	SOIL ASSOCIATION
108	571f	FYFIELD 3
109	571g	FYFIELD 4
110	571h	ARDINGTON
111	571i	HARWELL
112	571j	FRILSHAM
113	571k	MOULTON
114	571l	CHARITY 1
115	571m	CHARITY 2
116	571n	TATHWELL
117	571o	MELFORD
118	571p	ESCRICK 1
119	571q	ESCRICK 2
120	571r	HUNSTANTON
121	571s	EFFORD 1
122	571t	Efford 2
123	571u	SUTTON 1
124	571v	SUTTON 2
125	571w	Hucklebrook
126	571x	Ludford
127	571y	HAMBLE 1
128	571z	HAMBLE 2
129	571A	Rowton
130	572a	YELD
131	572b	MIDDLETON
132	572c	HODNET
133	572d	Whimple 1
134	572e	WHIMPLE 2

PROGRAM FILE NUMBER	MAP SYMBOL & SUB GROUP	SOIL ASSOCIATION
135	572f	WHIMPLE 3
136	572g	DUNNINGTON HEATH
137	572h	OXPASTURE
138	572i	CURTISDEN
139	572j	Bursledon
140	572k	BIGNOR
141	572l	FLINT
142	572m	SALWICK
143	572n	BURLINGHAM 1
144	572o	BURLINGHAM 2
145	572p	BURLINGHAM 3
146	572q	ASHLEY
147	572r	Ratsborough
148	572s	Bishampton 1
149	572t	BISHAMPTON 2
150	573a	WATERSTOCK
151	573b	Wix
152	581a	NORDRACH
153	581b	SONNING 1
154	581c	SONNING 2
155	581d	CARSTENS
156	581e	MARLOW
157	581f	BARROW
158	581g	STONE STREET
159	582a	BATCOMBE
160	582b	Hornbeam 1
161	582c	HORNBEAM 2

PROGRAM FILE NUMBER	MAP SYMBOL & SUB GROUP	SOIL ASSOCIATION
162	582d	HORNBEAM 3
163	582e	TENDRING
164	611a	MALVERN
165	611b	MORETONHAMPSTEAD
166	611c	MANOD
167	611d	WHITHNELL 1
168	611e	WHITHNELL 2
169	612a	PARC
170	612b	MOOR GATE
171	631a	ANGLEZARKE
172	631b	DELAMERE
173	631c	SHIRRELL HEATH 1
174	631d	SHIRRELL HEATH 2
175	631e	GOLDSTONE
176	631f	Crannymoor
177	633	LARKBARROW
178	634	SOUTHAMPTON
179	641a	SOLLOM 1
180	641b	Sollom 2
181	641c	HOLME MOOR
182	643a	Holidays Hill
183	643b	Poundgate
184	643c	Polderwood
185	643d	Felthorpe
186	651a	BELMONT
187	651b	Hexworthy
188	651c	EARLE

PROGRAM FILE NUMBER	MAP SYMBOL & SUB GROUP	SOIL ASSOCIATION
189	652	MAW
190	654a	HAFREN
191	654b	LYDCOTT
192	654c	Gelligaer
193	711a	STANWAY
194	711b	BROCKHURST 1
195	711c	BROCKHURST 2
196	711d	MARTOCK
197	711e	WICKHAM 1
198	711f	WICKHAM 2
199	711g	WICKHAM 3
200	711h	WICKHAM 4
201	711i	WICKHAM 5
202	711j	KINGSTON
203	711k	VERNOLDS
204	711l	CLAVERLEY
205	711m	SALOP
206	711n	CLIFTON
207	711o	RUFFORD
208	711p	DUNKESWICK
209	711q	PINDER
210	711r	BECCLES 1
211	711s	BECCLES 2
212	711t	BECCLES 3
213	711u	HOLDERNESS
214	711v	GRESHAM
215	711w	CROFT PASCOE

PROGRAM FILE NUMBER	MAP SYMBOL & SUB GROUP	SOIL ASSOCIATION
216	712a	DALE
217	712b	DENCHWORTH
218	712c	WINDSOR
219	712d	HALLSWORTH 1
220	712e	HALLSWORTH 2
221	712f	CREWE
222	712g	RAGDALE
223	712h	FOGGATHORPE 1
224	712i	FOGGATHORPE 2
225	713a	BARDSEY
226	713b	SPORTSMANS
227	713c	FFOREST
228	713d	CEGIN
229	713e	BRICKFIELD 1
230	713f	BRICKFIELD 2
231	713g	BRICKFIELD 3
232	714a	DUNKESWELL
233	714b	OAK 1
234	714c	OAK 2
235	714d	ESSENDON
236	721a	PRINCETOWN
237	721b	ONECOTE
238	721c	WILCOCKS 1
239	721d	WILCOCKS 2
240	721e	WENALLT
241	811a	ENBORNE
242	811b	CONWAY

PROGRAM FILE NUMBER	MAP SYMBOL & SUB GROUP	SOIL ASSOCIATION
243	811c	HOLLINGTON
244	811d	ROCKCLIFFE
245	811e	TANVATS
246	812a	FROME
247	812b	WISBECH
248	812c	AGNEY
249	813a	MIDELNEY
250	813b	FLADBURY 1
251	813c	FLADBURY 2
252	813d	FLADBURY 3
253	813e	COMPTON
254	813f	WALLASEA 1
255	813g	WALLASEA 2
256	813h	Dowels
257	814a	THAMES
258	814b	Newchurch 1
259	814c	NEWCHURCH 2
260	815	NORMOOR
261	821a	EVERINGHAM
262	821b	BLACKWOOD
263	831a	YEOLLANDPARK
264	831b	SESSAY
265	831c	WIGTON MOOR
266	832	KELMSCOT
267	841a	Curdridge
268	841b	HURST
269	841c	SWANWICK

PROGRAM FILE NUMBER	MAP SYMBOL & SUB GROUP	SOIL ASSOCIATION
270	841d	SHABBINGTON
271	841e	PARK GATE
272	851a	DOWNHOLLAND 1
273	851b	DOWNHOLLAND 2
274	851c	DOWNHOLLAND 3
275	861a	Isleham 1
276	861b	Isleham 2
277	871a	LAPLOYD
278	871b	HENSE
279	871c	HANWORTH
280	872a	PEACOCK
281	872b	Clayhythe
282	873	IRETON
283	92a	DISTURBED SOILS 1
284	92b	DISTURBED SOILS 2
285	92c	DISTURBED SOILS 3
286	1011a	LONGMOSS
287	1011b	WINTER HILL
288	1013a	CROWDY 1
289	1013b	CROWDY 2
290	1021	TURBARY MOOR
291	1022a	ALTCAR 1
292	1022b	ALTCAR 2
293	1024a	ADVENTURERS' 1
294	1024b	ADVENTURERS' 2
295	1024c	ADVENTURERS' 3
296	1025	Mendham

PROGRAM FILE NUMBER	MAP SYMBOL & SUB GROUP	SOIL ASSOCIATION
297	U	Unsurveyed, mainly urban and industrial areas.